Saskatchewan
Environment

Water Pollution
Control Branch

# Regina/Moose Jaw Drinking Water Quality, 1983

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# Regina/Moose Jaw Drinking Water Quality

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Water Pollution Control Branch

Saskatchewan Environment

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## SUMMARY

The drinking water in Regina and Moose Jaw was considered safe for consumption based on the 1983 monitoring, but the overall quality was poor during some months of the year, especially during July-August-September. No viruses were detected in any of the samples collected during October, 1983. Regina had more frequent bacterial problems than Moose Jaw plus higher amounts of debris and turbidity in the distribution system. Positive coliform results were not found in any of the treated water collected at the Buffalo Pound Filtration Plant during the year.

The purpose of this report and the 1983 monitoring results are summarized below. Remedial measures and improved monitoring of the water quality in both cities are recommended.

Purpose

There has been, over the last few years, considerable public concern about the quality of drinking water in Regina and Moose Jaw. The purpose of this report is to: gather together and evaluate the 1983 water quality information on the drinking water; report on additional monitoring completed in 1983 to supplement the ongoing testing; assess the acceptability of the treated water in terms of existing standards for drinking water quality; and make recommendations for remedial actions and future monitoring requirements should the need be shown.

## Background

Regina and Moose Jaw withdraw water from Buffalo Pound Lake for municipal purposes. The water from the lake is treated in the Buffalo Pound Filtration Plant which is jointly owned and operated by the two cities. The filtration plant provides conventional surface water treatment. Moose Jaw depends entirely on this supply whereas Regina obtains up to one-third of its supply from twenty-five wells located in and near the city. The ground water in Regina is untreated.

## Bacteria, Virus and Chlorine Results

The Cities of Regina and Moose Jaw are required by Saskatchewan Environment, as part of the operating approvals, to monitor their water distribution systems. The results for 1983 show that the total coliform levels exceeded the Saskatchewan Municipal Drinking Water Quality Objectives which state that "At least 90 per cent of the samples in any consecutive 30-day period should be negative for total coliform organisms and no one sample should contain more than 10 total coliform organisms per 100 mL. Properly operated municipal waterworks should be free of coliform bacteria." The Guidelines for Canadian Drinking Water Quality, which are very similar to the Saskatchewan objectives were also exceeded.

In August, 1983, 8.5 per cent of the samples from Regina tap water were positive for total coliforms. Twenty-one per cent of the samples were positive if overgrown counts were included in the calculation. The number of coliforms exceeded 10 organisms per 100 mL and therefore

exceeded the Saskatchewan objective in eight water samples from Regina and one sample from Moose Jaw during 1983.

The Saskatchewan objectives and the federal guidelines for drinking water both state that "none of the coliform organisms detected should be fecal coliforms."

Fecal coliform determinations are not, however, included in the monitoring requirements; therefore, there are no data to show whether or not the coliforms found in the distribution systems are of fecal origin.

Saskatchewan Environment conducted * a special study of the Regina-Moose Jaw distribution systems in October, 1983. Water samples were tested for actinomycetes, enteroviruses, total coliforms, fecal coliforms, fecal streptococci, and other bacteria: Pseudomonas Aeruginosa, Aeromonas sp. and Staphylococcus aureus.

Fourteen samples were collected in October, 1983, for virus analysis. The samples were collected from the raw and treated water at the Buffalo Pound Filtration Plant and the distribution systems in Regina and Moose Jaw. No viruses were detected in any of the samples.

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* - with the assistance of Dr. Sattar of the University of Ottawa, the Ontario Ministry of the Environment, the Cities of Regina and Moose Jaw, Health Region No. 2, the Provincial Laboratory and the Buffalo Pound Filtration Plant staff.

Aeromonas was found in two samples from Moose Jaw and several species of Pseudomonas were found in four samples from Regina. These bacteria occur widely in fresh water although they are potential pathogens.

There are many micro-organisms commonly present in treated drinking water whose numbers far exceed those of the coliform group. This general population is measured by the standard plate count [14]. The results of the standard plate counts showed that bacteria were generally common in both the distribution systems. The counts were, ~~counts showed that bacteria were generally common in both distribution systems.~~ however, relatively low and were consistent with adequate treatment.

The City of Regina also monitors the quality of water at wells and reservoirs which supply water to the distribution system. Results for 1983 showed that 50 per cent of the samples collected from wells in April and up to 37 per cent of the samples collected over the summer contained coliform bacteria. Sampling was carried out most often in areas where previous positive results had occurred. The highest frequency occurred in the North Regina Industrial area. The chlorinator servicing this area malfunctioned in 1983 and this contributed to the number of positive bacteria samples.

During October, 1983, the chlorine levels in the treated water at the Buffalo Pound Filtration Plant met Saskatchewan Environment's

regulation for chlorination. Free chlorine was absent in 80 per cent of the water samples from the Moose Jaw distribution system and total chlorine was absent in 15 per cent of the samples. Free chlorine was absent in 19 per cent of the Regina samples. Health and Welfare Canada recommends that a free chlorine residual be maintained to suppress the growth of organisms.

## Microscope Results

A microscopic examination of water collected during the October, 1983, study found $8.9 \times 10^6$ algae/L in treated (finished) water at the Buffalo Pound Filtration Plant. This is a reduction of 99.5 per cent of the algae that were present in the raw water. The number of algae in the Regina and Moose Jaw distribution systems averaged $1.2 \times 10^2$ and $1.7 \times 10^2$ algae/L. These numbers probably underestimate the maximum population present during 1983. Aquatic fauna including nematodes, rotifers and protozoans were mainly found in water samples from Moose Jaw. Iron bacteria were more prevalent in the Regina system although aquatic fauna have been found in Regina tap water in the past. Nematodes, protozoans and rotifers are common in Saskatchewan water bodies. These fauna may get into the system by passing through the filtration plant, by entering at the storage reservoirs and/or by growing within the distribution system.

## Algal Toxins

No harmful effects were seen on "chicks" in bioassay tests with treated water collected in 1982 from the Buffalo Pound Filtration Plant. If algal toxins were present, they were at low enough levels to have no observable effect.

Trace Organics

Tests for 77 organic compounds were completed on a sample of the treated water from the Buffalo Pound Filtration Plant. All compounds tested, except for two trihalomethane compounds, were not present at the limit of detection which was 10 ug/L. The trihalomethane concentration was well below the Saskatchewan drinking water quality objective.

Chemical Results

The provincial objective for uranium (0.02 mg/L), was exceeded in nine samples collected from wells in Regina after May. Since well water is mixed in varying ratios with treated water, these results do not necessarily mean that tap water exceeds the Saskatchewan objective.

The hardness of Regina water increases during the summer. The Saskatchewan objective of 800 mg/L, which acknowledges the higher mineral content of our water supplies, was always met. Levels of Total Dissolved Solids (TDS) in Regina water reached a maximum of 1,015 mg/L in August. The Saskatchewan objective for TDS was always met. Manganese levels in Regina water exceeded Saskatchewan objectives. Both the TDS and manganese guidelines are based on palatability and not health concerns. Manganese can also cause objectionable stains. Heavy metals, biocides and the other trace elements measured were below provincial and federal objectives.

The quality of Moose Jaw water is generally quite good with respect to water chemistry. The results reported in 1983 meet the Saskatchewan Drinking Water Quality Objectives.

# RECOMMENDATIONS

## General

1. The monitoring of the treated water throughout the systems should be reviewed and improved upon. Specific items to be considered are listed below:

   (a) simultaneous with the collection of bacteriological samples from the distribution systems, field tests should be conducted for total and free chlorine residual, pH, temperature and turbidity.

   (b) an evaluation of the presence and source of odours within the water storage reservoirs and distribution systems should be completed. This would likely include tests for threshold odour and actinomycetes.

   (c) additional testing should be conducted when water quality problems are the most likely; that is, in mid to late summer when the rate of biological growth is at a maximum. Because algal, bacterial and microfaunal populations can peak and disappear (usually in an unpredictable manner but possibly in sequence), sampling for this study should be repeated once a week at weekly intervals for approximately four to six weeks during this period. Sampling locations should include locations in the distribution systems and the Regina reservoirs and wells. The number of replicates taken at each location should be such that the significance of differences between sites can be assessed.

(d) since the Saskatchewan Municipal Drinking Water Quality Objectives state that none of the coliform organisms detected should be fecal coliforms, data on the presence or absence of fecal coliforms in treated water samples containing total coliform should be obtained. The fecal coliform test should be completed for all "repeat samples". This alone may not provide much information because the repeated sample will often be negative even though the original sample at that location was positive. Therefore, a representative number of coliform and background colonies especially during July-August-September should be "picked" and grown in EC Broth to determine if the colonies grow as a fecal organism.

(e) during July-August-September representative coliform and background colonies found in treated water samples should be "picked" and classified by the API 20E procedure.

(f) a sample of the treated water from the Buffalo Pound Filtration Plant should be analyzed for trace organics at the 1 ug/L level.

2. The water delivery pipelines from the Buffalo Pound Filtration Plant to the two cities should continue to be swabbed for cleaning purposes at least once per year or more often to maintain the hydraulic efficiency.

3. The frequency of cleaning the water storage reservoirs and pump house wet wells in Regina and Moose Jaw should be reviewed in light of the 1984-85 monitoring.

4. The federal government should be asked to increase research efforts into:

   (a) finding a less complex analytical method for the analysis of viruses in drinking water;

   (b) setting a limit on the virus content of drinking water; and

   (c) investigating the long-term effects of ingesting minute amounts of algal toxins.

Regina

5. The chlorination facilities in use in Regina should be better controlled and new facilities added where necessary to meet the requirements for chlorination specified in Saskatchewan Regulation 3/80. Disinfection of the water used by consumers, including well water should be ensured.

6. Options for reducing the turbidity levels in the Regina water storage reservoirs and the distribution system should be developed by the City of Regina. This should include a description of the principle of each option, the estimated annual cost and the advantages/disadvantages. Depending on the outcome of further monitoring the water quality in 1984-85, remedial measures to control the turbidity levels may be required. In the interim periodic flushing of the distribution lines should continue.

Moose Jaw

7. Chlorination facilities should be installed at the South Hill Reservoir in Moose Jaw and a more direct source of water should be

provided to the South Hill Reservoir from the Buffalo Pound Filtration Plant. The requirements of Saskatchewan Regulation 3/80 pertaining to chlorination should be met.

# Chapter 1

# INTRODUCTION

There has been, over the last few years, considerable public concern about the quality of drinking water in Regina and Moose Jaw. A high level of public concern was reached in the late summer of 1983, when hot dry weather caused high algal production in Buffalo Pound Lake and significant taste and odour problems in the two cities' drinking water. Many families sought alternative sources of drinking water.

Public and media attention is certainly aroused by the aesthetic quality of the water but attention is being increasingly focused on the health safety aspect. Many people are not convinced that the water supplies of Regina and Moose Jaw are safe to drink.

## 1.1 Purpose

The purpose of this report is to:

- gather together and evaluate the 1983 water quality information on the drinking water;
- report on additional monitoring to supplement the ongoing testing;
- assesss the acceptability of the treated water in terms of existing standards for drinking water quality; and to
- make recommendations for remedial actions and future monitoring requirements should the need be shown.

# Chapter 2

# BACKGROUND

## 2.1 The Water Supply Systems

### 2.1.1 Sources

#### (a) Buffalo Pound

Buffalo Pound Lake is an artificial reservoir in the Qu'Appelle River Valley approximately 30 kilometres long, one kilometre wide, with an average depth of about 3 metres and a surface area of about 2900 hectares (7200 acres).[1, 2*] Water is directed into the reservoir from Diefenbaker Lake via the Qu'Appelle River (see Figure 1).

The Buffalo Pound Water Administration Board was established to maintain and operate a water treatment plant to serve the Cities of Moose Jaw and Regina. The Buffalo Pound Filtration Plant is located about 3 kilometres south of the lake near the east end of the lake. The plant has a maximum capacity of 136 $dam^3$/day (30 mgd)**, with about 100 $dam^3$/day (22 mgd) to Regina and 36 $dam^3$/day (8 mgd) going to Moose Jaw.[1] Moose Jaw obtains all of its water needs from Buffalo Pound whereas Regina obtains up to one-third of its

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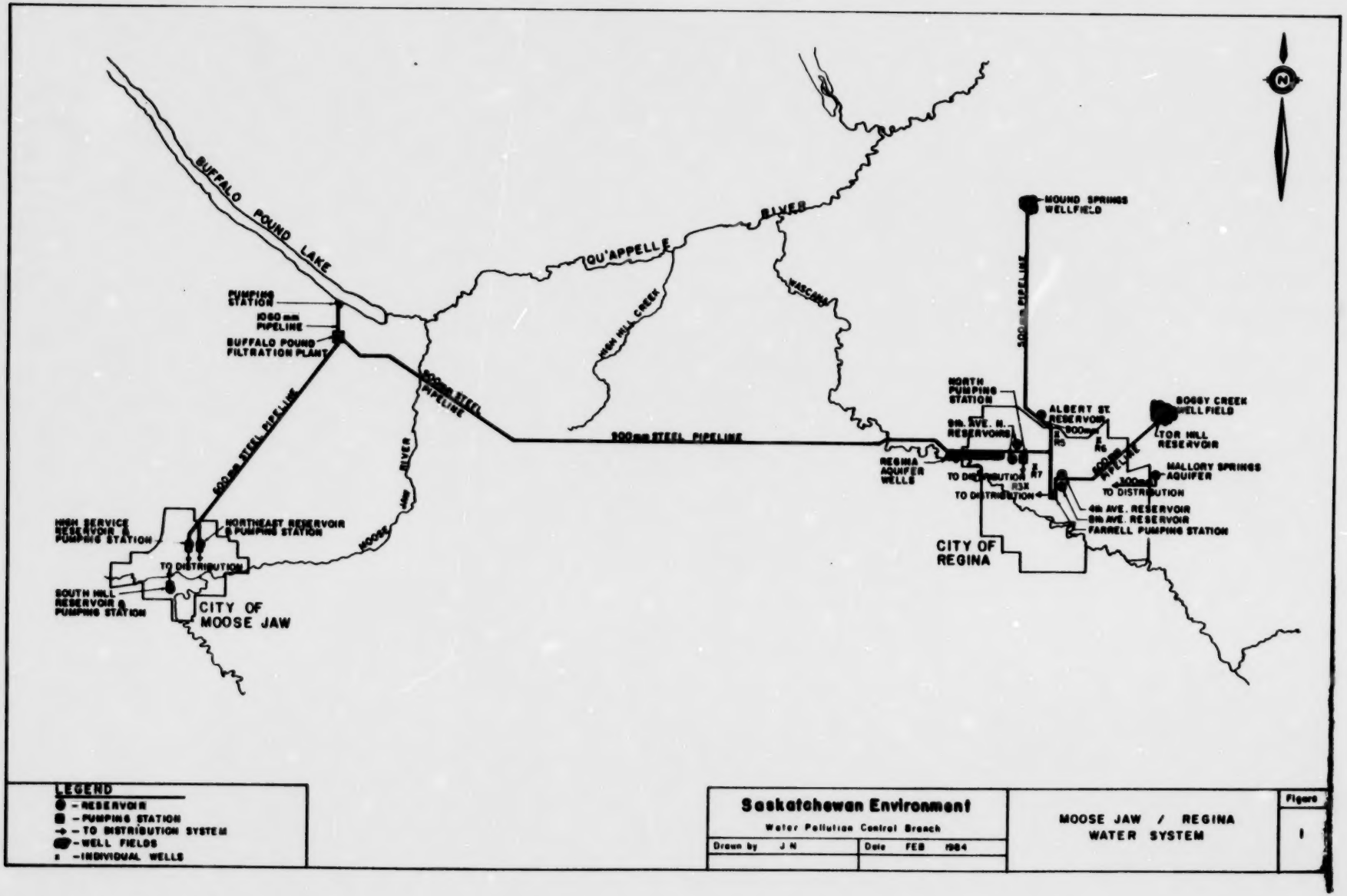
* 1, 2 - References listed in Appendix C.
** $dam^3$/day - cubic decametres per day; mgd - million gallons per day.


BUFFALO POUND LAKE
PUMPING STATION
1060 mm PIPELINE
BUFFALO POUND FILTRATION PLANT
600mm STEEL PIPELINE
600mm STEEL PIPELINE
QU'APPELLE RIVER
WASCANA
HIGH HILL CREEK
MOOSE JAW RIVER
900mm STEEL PIPELINE
HIGH SERVICE RESERVOIR & PUMPING STATION
NORTHEAST RESERVOIR & PUMPING STATION
TO DISTRIBUTION
SOUTH HILL RESERVOIR & PUMPING STATION
CITY OF MOOSE JAW
MOUND SPRINGS WELLFIELD
900mm PIPELINE
NORTH PUMPING STATION
9th AVE. N. RESERVOIRS
ALBERT ST. RESERVOIR
REGINA AQUIFER WELLS
TO DISTRIBUTION
TO DISTRIBUTION
BOGGY CREEK WELLFIELD
TOR HILL RESERVOIR
MALLORY SPRINGS AQUIFER
TO DISTRIBUTION
4th AVE. RESERVOIR
9th AVE. RESERVOIR
FARRELL PUMPING STATION
CITY OF REGINA
N
LEGEND
- RESERVOIR
- PUMPING STATION
- TO DISTRIBUTION SYSTEM
- WELL FIELDS
- INDIVIDUAL WELLS
Saskatchewan Environment
Water Pollution Control Branch
Drawn by J.N
Date FEB 1984
MOOSE JAW / REGINA WATER SYSTEM
Figure
1

water from well systems. Regina uses a higher percentage of well water in the high demand summer period.

A 600 mm diameter steel pipeline transports water approximately 20 km from the filtration plant to Moose Jaw's two north end reservoirs. A 900 mm diameter steel pipeline approximately 58 kilometres long carries water from the plant to the 9th Avenue North reservoir in Regina.[2]

(b) Regina Wells

The City of Regina obtains ground water from about 25 wells in four areas in or near the city. The four areas are: Boggy Creek well field; Mound Springs well field; Mallory Springs well field and Regina aquifer. These are all part of the Regina aquifer system.[1 2] The location of the well systems and their ties to the water distribution system are shown on Figure 1.

The amounts of water supplied by the wells varies considerably. The majority of ground water withdrawal occurs during the peak summer months with the rate decreasing over the winter.

2.1.2 Treatment

The Buffalo Pound Filtration Plant provides conventional surface water treatment. The process involves

prechlorination, chemical flash mix, coagulation, flocculation and sedimentation, rapid mixed-media filtration and post-chlorination. The cities have recently announced their intentions to proceed with carbon filtration treatment which is to be in place by mid-1985.

Water delivered to the City of Moose Jaw receives fluoride treatment before leaving the Buffalo Pound Filtration Plant, and is then pumped directly to their water storage/distribution system without further treatment. [3] [4] Water supplied from Regina's well systems receives no treatment for hardness, dissolved solids, iron or manganese reduction. [1]

Chlorination facilities at locations in Regina (North pumping station and Farrell pumping station) are used to maintain chlorine residuals in the Regina system.

2.1.3 Storage and Distribution

(a) Moose Jaw

The City of Moose Jaw currently has three main reservoirs (locations shown on Figure 1): [4] [6]

(i) High Service Reservoir:

- about 30 years old;
- two cells of 13,620 $m^3$ (3 mgal) each.*

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* $m^3$ - cubic metres,
mgal - million gallons.

(ii) South Hill Reservoir:

- into service in 1978;
- 9080 $m^3$ (2 mgal) capacity.

(iii) North East Reservoir:

- into service in 1983;
- 11,350 $m^3$ (2.5 mgal) capacity.

Water from Buffalo Pound Lake is directed into either the High Service Reservoir or the North East Reservoir. The South Hill Reservoir must be filled from the water distribution system.

All three of the reservoirs are associated with high capacity pumping systems in order to maintain adequate pressures within the distribution system. There are no disinfection facilities on the Moose Jaw water system. The chlorine added at the BPFP is relied on to maintain a residual in the system.

(b) Regina

The City of Regina maintains five main reservoirs, located as shown on Figure 1: [2 5]

(i) Tor Hill Reservoir:

- constructed in 1914;
- reinforced concrete;
- capacity 22,700 $m^3$ (5 mgal);
- filled from Boggy Creek wells.

(ii) Albert Street Reservoir:

- constructed of reinforced concrete in 1931;
- capacity 45,400 $m^3$ (10 mgal);
- obtains water from other reservoirs.

(iii) Fourth Avenue Reservoir:

- constructed in 1948 of reinforced concrete;
- capacity 45,400 $m^3$ (10 mgal);
- obtains water from other reservoirs.

(iv) Eighth Avenue Reservoir:

- constructed in 1914 of reinforced concrete;
- capacity 22,700 $m^3$ (5 mgal);
- filled from other reservoirs.

(v) 9th Avenue North Reservoirs:

- one constructed in 1970 of concrete - capacity of 22,700 $m^3$ (5 mgal);
- one constructed in 1979 of prestressed concrete with a capacity of 45,400 $m^3$ (10 mgal);
- the reservoirs are fed directly from the BPFP pipeline but can get water from other reservoirs in the city.

The City of Regina has two main pumping stations: the Farrell station (near the 8th Avenue reservoir) and the North pumping station (located at the 9th Avenue North reservoir). These two stations supply water directly to the Regina water distribution system.

Both stations have chlorination facilities for the feed into the distribution system.

The water supplied by wells enters the system at various places. The Boggy Creek wells supply water to the Tor Hill reservoir. The Mound Spring wells supply water to the Albert Street reservoir. Most of the Regina aquifer system wells pump into the water supply pipeline from the Buffalo Pound Filtration Plant upstream of the 9th Avenue North reservoir. The Mallory Springs wells pump water directly into the east Regina water distribution system. [2 5] Four wells in the Regina aquifer (Exhibition grounds, Uplands, Mount Pleasant, and Elphinstone) also pump water directly into the distribution systems. [5]

In summary, well water directly enters the Regina distribution system in the following places: North pumping station, Farrell pumping station, from the Mallory Springs wells, from four Regina aquifer wells within the city.

## 2.2 Monitoring - Cities - BPFP

### (a) Moose Jaw

Certificate No. 1285 was issued for the operation of Moose Jaw's municipal waterworks in April, 1982 and expires

December 1, 1986. The certificate requires that the city collect six samples per week of water from the distribution system for bacteriological quality determination and that samples be collected once per year for chemical quality, toxic chemicals (heavy metals) and biocides.

In addition the City of Moose Jaw was requested in September, 1983, to conduct the monitoring shown in Table 1 on samples collected from four locations in the distribution system. [8]

(b) Regina

Certificate No. 1321, was issued for the operation of Regina's municipal waterworks system in December, 1982 and expires on December 31, 1984.

The Certificate requires that the city collect sixteen samples per week of water from the distribution for bacteriological quality determinations. The certificate also requires that the monitoring shown in Table 2 be conducted.

In addition to the above monitoring the Buffalo Pound Water Administration Board has conducted "chick tests". These tests involved chicken bioassays to assess the quality of the Buffalo Pound Filtration Plant finished water for any

Table 1

City of Moose Jaw

Water Quality Monitoring

| Parameter | Frequency |
|---|---|
| Colour, temperature, turbidity | Quarterly |
| Alkalinity, Cl, Ca, Mg, Na, $SO_4$, pH, phenolics sum of dissolved ions, Cu, Fe, Mn, Zn | Quarterly |
| Ag, As, Ba, B, Cd, Cr, CN, Pb, Hg, $NO_3$, Se, U | 2/year |
| TTHM | 2/year (July-August) |
| Algae Identification and Enumeration, Actinomycetes | Quarterly |
| 2, 4-D, PCB, lindane, $\alpha$ BHC | Annually |

sublethal effects due to the presence of algal toxins. The bioassays were conducted by the Veterinary Services Branch, Saskatchewan Agriculture.

During the summer of 1982 and again in 1983, Dr. G. Slater, National Research Council, Saskatoon, conducted an investigation to determine the presence of organic compounds (which might be odour-causing) in Buffalo Pound Lake water, treated water and in the water entering the Regina and Moose Jaw water distribution systems. This investigation made no attempt to quantify any of these organic compounds.

TABLE 2

City of Regina

Water Quality Monitoring

| Location | Parameters | Frequency |
|---|---|---|
| Ground Water Supplies - all producing wells | Alkalinity, C, Ca, Mg, Na, $SO_4$, sum of dissolved ions, pH, Fe, Mn, Cu, Zn, phenolics. | Once every 2 years |
| | As, B, Ba, Cd, Cr, CN, Pb, Hg, $NO_3$, Se, Ag. | Once every 2 years |
| | U | Monthly |
| Wells W3, W4, R3, 14A, P2 (as above plus) | As | Once every 2 months |
| Buffalo Pound Filtration Plant - treated water | Colour, temperature, turbidity. | Weekly |
| | Alkalinity, Cl, Mg, Na, Ca, $SO_4$, sum of dissolved ions, pH, Fe, Mn, Zn, Cu, phenolics. | Monthly |
| | Ag, A, B, Ba, Cd, Cr, CN, Hg, Pb, Se, $NO_3$, U | Annually |
| | 2,4-D, PCBs, lindane, αBHC, herbicide scan | Annually |
| | TTHM | Monthly |
| Distribution System - 8 locations representative of areas within the City | Colour, temperature, turbidity | 2 per year |
| | TTHM | 2 per year |
| | Alkalinity, Ca, Cl, Mg, Na, $SO_4$, sum of dissolved ions, pH, Fe, Mn, Cu, Zn, phenolics | Quarterly |
| | Ag, As, B, Ba, Cd, Cr, CN, Hg, Pb, Se, $NO_3$, U. | Once every 2 years |
| | 2,4-D, PCBs, lindane, αBHC, herbicide scan | Annually (summer) |
| | Algae identification/enumeration, Actinomycetes | Quarterly |
| Distribution System - one location | U, As | Quarterly |

In January, 1983, a sample of treated water at the Buffalo Pound Filtration Plant was collected and analyzed for 77 organic compounds. The sample was analyzed at a New Jersey, USA, laboratory according to U.S. Environmental Protection Agency methodology.

## 2.3 Saskatchewan Environment Survey

In October, 1983, Saskatchewan Environment, Water Pollution Control Branch, arranged and conducted an intensive sampling program on the Moose Jaw/Regina water systems. The sampling program was conducted with the co-operation and assistance of personnel from the Regina Department of Health; the Moose Jaw Health Region No. 2 and staff from the University of Ottawa, School of Medicine. The following Table 3 shows the samples collected, locations of samples, when collected and the analytical laboratory.

The sampling and analytical methodology used to conduct the viral determinations is described in Appendix A. The samples collected for coliforms, fecal streptococci and standard plate count were collected in sterile bottles and examined by procedures described in Standard Methods for the Examination of Water and Wastewater, 15th Edition, [9] no later than the day following collection. Samples were refrigerated between sample collection and examination.

TABLE 3

WATER QUALITY MONITORING

REGINA/MOOSE JAW DRINKING WATER

| PARAMETERS | SAMPLE LOCATIONS | FREQUENCY OF SAMPLING | LABORATORY |
|---|---|---|---|
| 1. Viruses | BPFP-raw water<br>BPFP-treated water<br>Moose Jaw-tap water<br>Regina-tap water | 4<br>3 (Oct. 11-<br>3 Oct. 25)<br>4 | University of Ottawa, Dept. of Microbiology and Immunology, School of Medicine-Ottawa, Ont. |
| 2. Total Coliform<br>Fecal Coliform<br>Fecal Streptococci<br>(Positive tests on any treated water were picked and typed API 20E). | BPFP-raw water<br>BPFP-treated water<br>Regina-20 locations<br>Moose Jaw-10 locations | 2 at each site<br>(Oct. 11-12, 1983) | Provincial Laboratory, Regina |
| 3. Standard Plate Count | BPFP-treated water<br>Regina-20 sites<br>Moose Jaw-10 sites | 2 at each site<br>(Oct. 11-12, 1983) | Provincial Laboratory, Regina |
| 4. Special Bacteriological (aeromonas, pseudomonus aeruginosa, staphyloccus aureus) | BPFP-treated<br>Regina-4 locations<br>Moose Jaw-4 locations | 3 at each site<br>(Oct. 11-12, 1983) | Ministry of Environment Laboratory<br>Toronto, Ontario |
| 5. Actinomycetes | BPFP-treated<br>Regina-4 locations<br>Moose Jaw-4 locations | 1 at each location<br>(Oct. 11, 1983) | Ministry of Environment Laboratory<br>Toronto, Ontario |
| 6. Field Tests-chlorine residual, (total and free), pH, conductivity, turbidity | BPFP-raw BPFP-treated<br>Regina-20 sites<br>Moose Jaw-10 sites | Twice at each site | Field tests |
| 7. Microscopic examination (algae identification and enumeration, other organism identification) | BPFP-raw BPFP-treated<br>Regina-20 sites<br>Moose Jaw-10 sites | Once at each site | Saskatchewan Environment |

Samples in sterile bottles collected for special bacteriological examinations were packed with freezer packs in coolers and shipped by air freight to Toronto. The Ontario Ministry of the Environment (MOE) Microbiology Laboratory conducted a "Presence-Absence" test for Pseudomonas aeruginosa, Aeromonas sp. and Staphylococcus aureus (as well as total coliform, fecal coliform and fecal streptococcus).

Actinomycete samples were collected in sterile bottles and shipped by air freight to Toronto in coolers with freezer packs. The MOE Microbiology Laboratory used two methods of examination:

1. the procedure described in Section 916, p. 884 of Standard Methods [9]
2. a modification of the Standard Methods procedure in an effort to utilize a larger volume of sample. A 100 ml aliquot of sample wasfiltered through a membrane filter and the filters transferred to agar medium and incubated.

The field testing was conducted at each sampling site using portable field instruments for chlorine residual (free and total), pH, conductivity, turbidity and temperature.

Samples for phytoplankton examination were collected, preserved in the field and later examined microscopically for the presence of algal cells, and other organisms such as nematodes, amoeba, etc.

## Chapter 3

## CITY OPERATION AND MAINTENANCE PROGRAMS

### 3.1 Buffalo Pound Filtration Plant

Staff at the Buffalo Pound Filtration Plant conduct regular intensive sampling and analytical programs at the plant as process control. Parameters such as turbidity, particle counts, bacterial examinations, threshold odour determinations, pH, conductivity, etc. are conducted in efforts to control and improve the water treatment process.

### 3.2 Moose Jaw

The 600 mm steel pipeline from Buffalo Pound Filtration Plant to the cities' two reservoirs is swabbed on an annual basis to maintain the hydraulic efficiency of the line. The material dislodged is analyzed by personnel at the Buffalo Pound Filtration Plant. [6]

Moose Jaw's three reservoirs and pumping stations are cleaned on a five year basis. The Northeast Reservoir came into service in 1983. One cell of the High Service Reservoir and the South Hill Reservoir were cleaned in 1983. [6] The other cell of the High Service Reservoir was cleaned three years ago. [4] The reservoirs are washed, scrubbed down then washed with high pressure water jets using heavily chlorinated water.

The City of Moose Jaw does not conduct a regular flushing or swabbing program on the distribution system. The water is monitored regularly for bacterial problems. When the testing indicates a coliform count, flushing is conducted in that area. In very severe causes, foam swabbing is undertaken.

As mentioned previously the City of Moose Jaw does not routinely add chlorine to the water, but relies on the residual chlorine applied at the Buffalo Pound Filtration Plant.

## 3.3 Regina

The 900 mm pipeline from Buffalo Pound Filtration Plant to the 9th Avenue North reservoir is generally swabbed once per year but in 1983 was swabbed in May and October.

All of Regina's storage reservoirs were cleaned in 1983 (by early summer).[7] The reservoirs were washed down, scrubbed down then washed with heavily chlorinated water. The city's normal reservoir cleaning program is to clean every five years but this frequency is under review.[5]

The city conducts a regular water main flushing program in the spring of each year and an additional flushing program at troublesome locations each fall. Consumer complaints and/or regular bacterial testing is used to locate troublesome sites. The city has not, in the past, conducted any foam swabbing of mains or distribution lines.[7]

The Regina water system has a potential for turbidity problems due to the mixing of well water (with relatively high levels of iron and manganese), with water from Buffalo Pound Lake and with the addition of chlorine.

As mentioned previously, chlorine is added at the North and Farrell pumping stations to maintain a residual in the distribution system. A total chlorine level of 1.0 mg/L is maintained at these locations in the summer and a level of 0.9 mg/L is maintained in the winter.

# Chapter 4

# 1983 MONITORING RESULTS

## 4.1 Viruses

A virological examination for the presence of detectable enteric viruses was undertaken for Saskatchewan Environment by Dr. Syed Sattar, Department of Microbiology and Immunology, University of Ottawa. A trained technician and all necessary equipment were sent to Regina to ensure that correct procedures were used for sample collection, processing and storage of sample concentrates. Fourteen samples (Table 4) were concentrated and sent to Ottawa for analysis. A detailed description of the methods and materials is contained in Dr. Sattar's report (appended). Water samples were collected from the raw and treated water at the Buffalo Pound Filtration Plant and the distribution system of Regina and Moose Jaw.

No cytopathogenic viruses were detected in any of the 14 sample concentrates obtained (Table 4). To detect the presence of non-cytopathogenic viruses, the cell culture material was examined by electron microscopy. All samples proved to be negative but only a large number of non-cytopathogenic viruses could be detected by this method. The detection limit is $10^6$ particles/mL.

Although important advances have been made in the recovery of viruses from water samples, not all enteric viruses can be detected. For example, the causative agents for hepatitis A still

TABLE 4

RESULTS OF VIROLOGICAL EXAMINATION OF THE REGINA-MOOSE JAW DRINKING WATER, OCTOBER 1983

| SAMPLE NO. | TYPE | LOCATION | VOLUME PROCESSED (L) | pH | TURBIDITY (f.t.u.) | TEMPERATURE °C | CULTURES SHOWING CPE* / CULTURES INOCULATED Ma104 CELLS | BS-C-1 CELLS |
|---|---|---|---|---|---|---|---|---|
| 1 | Raw | BPL** | 40 | 8.6 | 3.0 | 8.0 | 0/10(0/10) | 0/10(0/10) |
| 2 | Raw | BPL | 40 | 8.6 | 3.0 | 8.0 | 0/10(0/10) | 0/10(0/10) |
| 3 | Raw | BPL | 40 | 8.6 | 3.0 | 8.0 | 0/10(0/10) | 0/10(0/10) |
| 4 | Raw | BPL | 40 | 8.6 | 3.0 | 8.0 | 0/10(0/10) | 0/10(0/10) |
| 5 | Treated | BPWTP*** | 300 | 7.8 | 0.18 | 8.0 | 0/10 | 0/10 |
| 6 | Treated | BPWTP | 282 | 7.4 | 0.13 | 6.0 | 0/10 | 0/10 |
| 7 | Treated | BPWTP | 318 | 7.8 | 0.13 | 6.0 | 0/10 | 0/10 |
| 8 | Treated | Moose Jaw | 291 | 7.6 | 0.19 | 8.0 | 0/10 | 0/10 |
| 9 | Treated | Moose Jaw | 264 | 7.6 | 0.19 | 8.0 | 0/10 | 0/10 |
| 10 | Treated | Moose Jaw | 300 | 7.6 | 0.19 | 8.0 | 0/10 | 0/10 |
| 11 | Treated and ground | Regina | 341 | 7.6 | 0.94 | 9.0 | 0/10 | 0/10 |
| 12 | Treated and ground | Regina | 286 | 7.5 | 2.96 | 9.0 | 0/10 | 0/10 |
| 13 | Treated and ground | Regina | 345 | 7.5 | 3.02 | 9.0 | 0/10 | 0/10 |
| 14 | Treated and ground | Regina | 355 | 7.3 | 1.53 | 10.0 | 0/10 | 0/10 |

*Figures in parentheses are results for ten-fold dilutions of sample concentrations. CPE = Cytopathogenic Effects.

**BPL = Buffalo Pound Lake.

***BPWTP = Buffalo Pound Water Treatment Plant.

BS-C-1 Cells = obtained from Laboratory Centre for Disease Control, Ottawa.

Ma 104 Cells = obtained from Gull Labs., Utah.

cannot be readily cultivated even though more than 50 water-borne epidemics of infectious hepatitis have been documented worldwide.[10] Host cells from two different types of continuous lines were used to increase the spectrum of viruses that could be detected.

The densities of viruses are usually so low in treated water supplies that large volumes of water must be concentrated. The average sample size of 300 L used in Dr. Sattar's study is within the recommended range for drinking water[9].

The procedure concentrates other types of organic matter as well as viruses. This creates several problems for raw water samples. Firstly, the volume of water that can be processed is reduced (Table 4). Secondly, the organic matter that has been concentrated can interfere with replication of the viruses. To overcome this effect, diluted as well as undiluted concentrations of raw water were innoculated into the cell cultures.

The virological examination was part of an intensive study in October, 1983. However, the virus content of surface waters and ground waters varies considerably both seasonally and daily.[11] In temperate climates, enteric viruses occur at peak levels during late summer and early fall[9] although infectious hepatitis may be an exception.*

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* - The incidence of infectious hepatitis may increase in colder months.9

In summary, no viruses were detected in the 14 water samples collected in October, 1983. Advances have been made in virus analysis but the procedures are complex and there are still limitations that need to be improved upon by research on the methodology.

The World Health Organization (WHO)[16] says that drinking water free of viruses can be achieved:

"(a) by the use of a water supply from a source which is free from wastewater and is protected from faecal contamination; or

(b) by the adequate treatment of a water source that is subject to faecal pollution."

In addition WHO[16] says:

"Adequacy of treatment cannot be assessed in an absolute sense because neither monitoring technique nor epidemiological evaluation is sufficiently sensitive to ensure the absence of viruses or the freedom from endemic occurrences of waterborne infections. However, it is considered at present that contaminated source water may be regarded as adequately treated when the following conditions are met:

- turbidity at one NTU or less is achieved;
- disinfection of the water with at least 0.5 mg/L of free residual chlorine after a contact period of at least 30 minutes at a pH below 8.0."

The water supply from Buffalo Pound Lake does not receive any known direct wastewater discharges that could contain viruses known to be infectious to man. Potential municipal sources in Alberta are far removed from Buffalo Pound Lake and are not considered a significant threat to the lake. In addition, the treated water at the Buffalo Pound Filtration Plant meets both the turbidity and chlorination objective for "adequate treatment" as described above by the WHO. It should be noted however, that chlorine was undetectable in 15 per cent of the Moose Jaw tap water samples and that unchlorinated well water enters the system in Regina.

## 4.2 Bacteria and Chlorine Residuals

### 4.2.1 Total Coliform and Background Bacteria

As part of their licensing requirements, the City of Regina and Moose Jaw must submit 16 and 6 water samples per week, respectively, from their distribution systems to the Provincial Laboratory, Regina. Results of the total coliform tests are sent to Saskatchewan Environment. Results for any sample are considered positive when coliform (sheen) colonies are identified on the medium or when the medium is overgrown with more thatn 300 background colonies/100 mL. [12] Such overgrowth would interefere with the development of typical coliform colonies. When results are positive for total coliforms, a repeat sample from the same location is required.

The 1983 total coliform tests for Regina summarized in Table 5, show an increase in positive results for July, August and September. In August, 8.5 per cent of the samples were positive for total coliforms and 21 per cent of the samples were positive if overgrown counts are included in the calculation. The Saskatchewan Drinking Water Quality Objectives[13] state that "At least 90 per cent of the samples in any consecutive 30 day period should be negative for total coliform organisms...". The Guidelines for Canadian Drinking Water Quality 1978 [14] and the Ontario Drinking Water Objectives [15] also limit the number of positive total coliform. Regina drinking water did meet this part of the provincial objectives and federal guidelines in August, 1983, for total coliforms but if the overgrown samples are included, the 10 per cent objective is not met. An overgrown sample is one where more than 300 background organisms/mL occur making it very difficult to detect if coliform organisms are or are not present.

The Saskatchewan drinking water quality objectives and the federal guidelines state that "...no one sample should contain more than 10 total coliform organisms per 100 mL." The Ontario Ministry of the Environment sets a density of 5 organisms per 100 mL [15]. Table 6 which lists all positive coliform and background colony results for Regina tap water in 1983 shows 8 occasions when coliform levels have exceeded 10 organisms/100 mL and, therefore, the

TABLE 5

RESULTS OF TOTAL COLIFORM TESTS FROM WATER SAMPLES COLLECTED AT POINTS IN THE REGINA - MOOSE JAW DISTRIBUTION SYSTEMS, 1983 (NO. OF SAMPLES)

| | REGINA | | | MOOSE JAW | | |
|---|---|---|---|---|---|---|
| DATE 1983 | NEGATIVE | POSITIVE* | PERCENT POSITIVE* | NEGATIVE | POSITIVE* | PERCENT POSITIVE* |
| January | 95 | 2 | 2.1 | 36 | 1 | 2.7 |
| February | 92 | 1 | 1.1 | 26 | 0 | 0 |
| March | 99 | 1 | 1.0 | 27 | 1 | 3.6 |
| April | 54 | 0 | 0 | 24 | 0 | 0 |
| May | 62 | 1 | 1.6 | 24 | 1 | 4.0 |
| June | 49 | 1 | 2.0 | 16 | 0 | 0 |
| July | 73 | 7 | 9.6 | 25 | 1 | 3.9 |
| August | 71 | 15 | 21.1 | 33 | 2 | 5.7 |
| September | 57 | 4 | 7.0 | 26 | 1 | 3.7 |
| October | 72 | 1 | 1.4 | 25 | 1 | 3.9 |
| November | 74 | 3 | 3.9 | 21 | 0 | 0 |
| December | 72 | 3 | 4.0 | 13 | 0 | 0 |

*Cultures that contain coliform bacteria or are overgrown (>300 organisms/100 mL) are considered positive.

TABLE 6

BREAKDOWN OF POSITIVE TOTAL COLIFORM AND BACKGROUND BACTERIA RESULTS*, REGINA WATER DISTRIBUTION SYSTEM, 1983 (NUMBER OF ORGANISMS/100 ML)

| DATE | COLIFORM | BACKGROUND | DATE | COLIFORM | BACKGROUND |
|---|---|---|---|---|---|
| January 6 | 4 | - | August 10 | - | 67 |
| January 12 | - | >100 | August 11 | - | 16 |
| January - | - | OG | August 11 | - | 76 |
| February 10 | - | OG | August 11 | 2 | 13 |
| February 14 | - | 7 | August 11 | - | >200 |
| February 14 | - | 15 | August 15 | 1 | 5 |
| March 17 | - | >100 | August 15 | 47 | - |
| March 24 | - | OG | August 15 | - | OG |
| April 25 | - | 7 | August 15 | - | OG |
| May 9 | - | 29 | August 16 | - | OG |
| May 26 | - | 3 | August 17 | 4 | - |
| May 30 | 3 | - | August 17 | - | OG |
| June 2 | - | 20 | August 18 | - | 1 |
| June 2 | - | 2 | August 18 | - | >200 |
| June 2 | - | >100 | August 18 | - | 140 |
| June 2 | - | OG | August 22 | - | >100 |
| July 4 | >100 | - | August 22 | >100 | - |
| July 7 | - | OG | August 25 | >16 | - |
| July 9 | - | 40 | September 6 | >100 | - |
| July 9 | - | 76 | September 8 | - | 19 |
| July 11 | - | OG | September 12 | - | OG |
| July 14 | - | 27 | September 12 | - | 15 |
| July 14 | - | 150 | September 12 | 1 | 23 |
| July 21 | - | >300 | September 21 | - | OG |
| July 21 | 1 | - | October 13 | - | OG |
| July 25 | 22 | - | October 17 | - | 120 |
| July 28 | - | OG | October 31 | - | 28 |
| July 28 | - | OG | November 10 | 1 | - |
| August 2 | - | OG | November 17 | 1 | - |
| August 4 | - | 6 | November 29 | 1 | - |
| August 4 | - | OG | December 12 | 53 | - |
| August 8 | - | OG | December 15 | 11 | - |
| August 10 | - | OG | December 22 | - | OG |
| August 10 | - | OG | | | |

*See Table 5 for total results.

**OG = overgrown

Saskatchewan objectives. These exceedences occurred in July, September and December. Large numbers of background bacteria were also fairly common.

The 1983 total coliform tests for Moose Jaw (Table 5) show fewer positive results. At no time did the number of positive samples exceed 10 per cent in a 30 day period. The maximum was 5.7 per cent in August and includes both total coliforms and overgrowth. One sample collected in August exceeded the Saskatchewan objective because it contained more than 10 coliforms/100 mL (Table 7).

About 20 samples of treated water per month were analyzed for total coliforms and fecal coliforms at the Buffalo Pound Filtration Plant. Coliforms were not found in any of the samples.[23] As part of an interim study in October, 1983, Saskatchewan Environment tested many water samples from the Regina and Moose Jaw distribution systems for total coliform bacteria, standard plate count, and chlorine residuals.

Total coliforms were absent in all samples at all locations (Table 8). Background colonies were absent in the finished water samples of the Buffalo Pound Filtration Plant but present in three of the Moose Jaw water samples and seven of the Regina water samples.

TABLE 7

BREAKDOWN OF POSITIVE TOTAL COLIFORM AND BACKGROUND BACTERIA RESULTS*, MOOSE JAW WATER DISTRIBUTION SYSTEM, 1983 (NUMBER OF ORGANISMS/100 ML)

| DATE | COLIFORMS | BACKGROUND |
|---|---|---|
| January 17 | 2 | - |
| March 14 | - | OG ** |
| April 11 | - | 45 |
| May 2 | 1 | 70 |
| July 18 | - | OG |
| July 18 | - | 170 |
| August 2 | - | OG |
| August 29 | >100 | - |
| August 29 | - | 11 |
| September 26 | 1 | - |
| October 17 | 1 | - |

*see Table 5 for total results.

**OG = overgrown.

TABLE 8

RESULTS OF PART OF THE BACTERIAL EXAMINATION OF THE REGINA - MOOSE JAW DRINKING WATER, OCTOBER 1983
(REMAINING PARTS PRESENTED IN SECTIONS 4.2.2 and 4.2.3)

| | UNITS | NUMBER OF SAMPLES | MEAN | STANDARD DEVIATION | MEDIAN | MAXIMUM | 75TH PERCENTILE |
|---|---|---|---|---|---|---|---|
| **Buffalo Pound** | | | | | | | |
| **Treated Water** | | | | | | | |
| Total Coliforms | No/100 mL | 7 | 1* | 0 | <1 | <1 | <1 |
| Background Colonies | No/100 mL | 2 | 1* | 0 | - | <1 | - |
| Standard Plate Count | No/mL | 2 | 1* | - | - | 1 | - |
| Chlorine, Total | mg/L | 5 | 1.4 | 0 | 1.4 | 1.4 | 1.4 |
| Chlorine, Free | mg/L | 5 | 1.0 | 0 | 1.0 | 1.0 | 1.0 |
| **Moose Jaw** | | | | | | | |
| **Municipal Distribution** | | | | | | | |
| Total Coliforms | No/100 mL | 35 | 1* | 0 | <1 | <1 | <1 |
| Background Colonies | No/100 mL | 13 | 1.6* | 2.6* | <1 | 18 | <1 |
| Standard Plate Count | No/mL | 31 | 6* | 6* | 4 | 162 | 19 |
| Chlorine, Total | mg/L | 20 | 0.5 | 0.3 | 0.5 | 1.2 | 0.7 |
| Chlorine, Free | mg/L | 20 | 0.2 | 0.1 | <0.1 | 0.6 | <0.1 |
| **Regina Municipal Distribution** | | | | | | | |
| Total Coliforms | No/100 mL | 52 | 1* | 0 | <1 | <1 | <1 |
| Background Colonies | No/100 mL | 12 | 4* | 5* | 1.2 | 57 | 14 |
| Standard Plate Count | No/mL | 47 | 4* | 4* | 3 | 116 | 8 |
| Chlorine, Total | mg/L | 42 | 0.7 | 0.3 | 0.7 | 1.4 | 1.0 |
| Chlorine, Free | mg/L | 42 | 0.4 | 0.3 | 0.4 | 0.9 | 0.6 |

*Mean and standard deviation are geometric. < signs were ignored.

There are many micro-organisms commonly present in treated drinking water whose numbers far exceed those of the coliform group. This general population is measured by the standard plate count [14]. The results of the standard plate counts showed that bacteria were generally common in both distribution systems: they were present in more than half of the water samples, but the counts were relatively low. The highest counts in Regina and Moose Jaw were 116 and 162 organisms per mL respectively (Table 8). The Canadian Guidelines do not set a maximum acceptable level for standard plate count but levels of less than 500 organisms per mL are considered to be consistent with adequate treatment [14].

The results of the special study are consistent with the results of the regular monitoring program. Both showed that coliform were absent or rarely present during October.

The coliform group of bacteria is the most widely accepted indicator of drinking water quality [13, 14, 15, 16]. It does not, however, meet all of the criteria of an ideal indicator all of the time. This group may be present in unpolluted waters; but that is, when potential pathogens are absent. It may also be absent when some pathogens are present. Although other alternatives such as the faecal coliform group are sometimes recommended [17], a single ideal

indicator does not exist. Saskatchewan Environment supplemented the total coliform results by a special study that tested for alternate indicators and specific bacteria (Sections 4.2.2 and 4.2.3).

So far, all the results presented in this section (4.2.1) pertain to water in the distribution system but the City of Regina also tests the wells and reservoirs which supply water to the system. Table 9 presents the total coliform test results for these reservoirs and wells.

The number of coliform bacteria in Regina wells and reservoirs increased markedly in April, 1983; 50 per cent of the samples contained total coliform bacteria. The geometric mean for that month, 2.4 organisms/100 mL, was the highest mean recorded for 1983. The peak was centered in the North Regina Industrial area. High numbers of samples containing coliforms also occurred in the summer; from 30 per cent to 37 per cent of the samples contained coliforms in July, August and September.

It should be noted that the majority of these wells and reservoirs are located upstream of the Regina North and Farrell pumping stations where chlorination occurs. The City of Regina supplies water to the North Regina Industrial area. The water distribution system in that area, including the chlorination facilities, is operated by

TABLE 9

TOTAL COLIFORM BACTERIA IN THE CITY OF REGINA WATER SUPPLY SYSTEM, 1983 (RESERVOIRS AND WELLS)*

| | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Coliforms/100 mL | | | | | | | | | | | | |
| Number of Samples | 23 | 10 | 10 | 50 | 95 | 67 | 91 | 83 | 64 | 68 | 30 | 4 |
| Number of Samples Containing Coliform Results | 0 | 0 | 0 | 25 | 16 | 17 | 28 | 27 | 19 | 13 | 6 | 0 |
| Number of Samples >10/100 mL | 0 | 0 | 0 | 11 | 6 | 4 | 8 | 4 | 1 | 0 | 0 | 0 |
| **Mean Coliforms/ 100 mL | 0 | 0 | 0 | 2.7 | 0.4 | 0.6 | 0.9 | 0.6 | 0.4 | 0.3 | 0.3 | 0 |
| Maximum Coliforms/ 100 mL | 0 | 0 | 0 | 100 | 100 | 53 | 100 | 46 | 48 | 10 | 4 | 0 |

*Provided by the City of Regina.

**geometric means.

the Rural Municipality of Sherwood. Operational problems occurred with the chlorinator during the summer of 1983 and that may account for the high incidence of positive samples in the North Regina Industrial area.

### 4.2.2 Chlorine Residuals

Although an average of 1.4 mg/L of chlorine residual including 1.0 mg/L of free chlorine was measured in the finished water leaving the filtration plant, free chlorine was not detected in 80 per cent of the Moose Jaw samples. The total chlorine residual averaged 0.5 mg/L in Moose Jaw and in 15 per cent of the samples total residual chlorine was undetectable. Since Regina chlorinates its water supply at two locations, the chlorine residuals were higher there. A total chlorine residual was always present in the October samples. In 17-19 per cent of the samples the total chlorine residual had dropped to 0.3 mg/L and free chlorine was undetectable in some samples (Table 8).

Maintaining a chlorine residual suppresses the growth of organisms within the system and affords some protection against small invasions from outside the system. Section 33 of Saskatchewan's Waterworks Regulation 3/80 states: "33. Unless otherwise approved in writing by the minister, the owner of a waterworks distribution system shall cause to be maintained:

(a) a free chlorine residual of not less than 0.1 mg/L in the water entering a distribution system; or

(b) a total chlorine residual of not less than 0.5 mg/L, based on a 5 minute orthotolidine test, at the most distant point in a distribution system."

Health and Welfare Canada [14] recommends that a free chlorine residual be maintained and monitored daily throughout the distribution system although excessive levels of free chlorine may result in taste and odour problems. This recommendation is not met by the City of Moose Jaw and not always met by the City of Regina.

### 4.2.3 Fecal Coliform and Fecal Streptococci

Water samples from Buffalo Pound Lake opposite the filtration plant were tested for fecal coliform and fecal streptococci three times in 1983: once in January and twice in July. No fecal streptococci were present but 2 fecal coliform per 100 mL were present in one of the lake water samples collected in July. A water quality study was conducted during 1981-82 at that location [18] and reported a geometric mean of 2 fecal coliform/100 mL and a median of <1 fecal coliform/100 mL based on 34 samples. Thus, the 1983 results are quite typical. The 1981-82 study also reported a geometric mean of 4 fecal streptococci/100 mL although fecal streptococci were often absent in individual samples.

Saskatchewan Environment also collected two samples of finished water at the Buffalo Pound Filtration Plant in 1983. Fecal coliform and fecal streptococci were absent.

During the intensive sampling program on October 11 and 12, 20 and 41 water samples were collected at points in the Moose Jaw and Regina distribution systems respectively. Fecal coliform and fecal streptococci were not detected in any sample.

The fecal coliform and fecal streptococci results were consistent with the total coliform results from the October study. One would not expect to find fecal coliform when total coliform were absent. Generalizations should not be drawn from these results because of the timing and short duration of the study. The total coliform monitoring has shown that indicator bacteria are less likely to be detected in October than August. Even in August, they may be undetectable over a two-day period.

Fecal coliform testing is not included in the routine monitoring required by Saskatchewan Environment in the cities' licences. The Municipal Drinking Water Quality Objectives [13], however, state that none of the coliform organisms detected should be fecal coliforms. The 1983 monitoring data indicated that total coliforms were occasionally present in the distribution system, especially

in August, but there were no corresponding fecal coliform data to indicate whether the objective has been met.

4.2.4 Other Indicator Bacteria

As part of an intensive testing program on October 11 and 12, 1983, Saskatchewan Environment sent 12 tap water samples (4 of which were duplicates) from the Moose Jaw distribution system and 7 tap water samples (3 of which were duplicates) from the Regina system, and 1 sample of treated water from the Buffalo Pound Filtration Plant to the Ontario Ministry of the Environment, Laboratory Services Branch. A set of presence/absence tests for total coliform group, fecal coliform group, fecal streptococcus group; Pseudomonas aeruginosa, Aeromonas sp. and Staphylococcus aureus were performed on each sample that was positive in the presumptive test.

The presumptive test results were positive for 7 of the Moose Jaw samples, 2 of the Regina samples and the treated water sample from the Buffalo Pound Filtration Plant. All other samples were negative. The samples with positive presumptive tests did not have any of the bacteria listed above except for 2 samples from Moose Jaw which had Aeromonas sp. Although Aeromonas is a potential enteropathogen, it occurs widely in fresh waters. The other bacteria included in the test were absent.

At the same time that samples were sent to Ontario, tap water samples were also sent to the Provincial Laboratory, Regina. Coliform or background colonies grown from these samples were then analyzed by the API 20E procedure.

The Provincial Laboratory identified Pseudomonas in four of the samples from the Regina distribution system. The Pseudomonas were P. maltophilia, P. fluorescens and two unidentified species. A sample of raw water from Buffalo Pound Lake contained Enterobacter agglomerans, Enterobacter cloacae, and Plesiomonas shigelloides.

Although Pseudomonas species are commonly saprophytic, the two species identified in the Regina tap water samples are of interest. They are potential human pathogens but they have a low virulence [19] (that is, they are more likely to be present in patients with reduced defence mechanisms or present as a secondary infection). The two species of Enterobacter found in the raw water have been isolated from man, sewage, animal feces, soil, many plants and fresh water. They are opportunistic pathogens that have been associated with respiratory, urinary and nosocomial infections but they are not limited to these [19]. Plesiomonas shigelloides is primarily an inhabitant of mud and fresh water.

### 4.2.5 Actinomycetes

Actinomycetes are filamentous branching bacteria which are known to produce geosmin. Geosmin has a very distinctive earthy musty odour in water. For this reason, levels of actinomycetes in drinking water are of interest.

Nine water samples collected from the Regina distribution system on October 12, 1983, were anlayzed by the Ontario Ministry of the Environment, Laboratory Services Branch. Two techniques were used to detect the presence of actinomycetes: the first followed standard methods [9] using casein starch agar, and the second modified the standard method so that membrane filtration could be used to concentrate the organisms from a larger volume of water.

No actinomycetes were found in the water samples; the results for both methods were negative. The growth of actinomycetes is temperature dependent; most actinomycetes are mesophiles requiring at least 15°C. Optimal temperatures would be higher. The distribution systems may be too cold in October to allow actinomycete growth.

In 1981-82, actinomycete analysis was included in an intergovernmental study [18] of the upper Qu'Appelle River including Buffalo Pound Lake. Two different media were used by the Regina Water Research Institute (Dr.Cullimore):

Actinomycetes Isolation Agar and chitin media. The latter resulted in fewer positive results. The geometric mean for Buffalo Pound Lake opposite the water treatment plant was $4.5 \times 10^3$/mL* in the summer of 1981 and 2/mL* in the summer of 1982. The difference in results was probably due to dramatic changes in plankton and/or the change in method. Increases in theshold odour numbers in the treatment plant raw water were not correlated with increases of actinomycetes in the lake.

An additional investigation of the odour and actinomycete levels in the pipelines bringing water from the Buffalo Pound Filtration Plant to Regina and Moose Jaw was carried out on seven occasions during the summer of 1982 [18]. Samples were taken after the water had flowed through the pipeline from Buffalo Pound Lake but before it entered the cities' distribution systems.

Actinomycetes were never detected in any of the water samples collected during this additional study. Threshold odour numbers at the four sampling points were usually the same as or slightly less than the threshold odour numbers measured in the finished water at the Buffalo Pound Filtration Plant.

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* Based on 10 and 16 samples respectively spread over the summer.

The odour in Regina's and Moose Jaw's tap water could be contributed by actinomycetes growing in the lake, in the filtration plant and in the storage reservoirs and distribution systems. Raw water from Buffalo Pound Lake has been reported [18] to have significant odours. There is insufficient data at this time to determine the relative contribution to the odour in the tap water, from actinomycetes growing in different parts of the water system.

## 4.3 Other Aquatic Organisms

On October 11 and 12, 1983, Saskatchewan Environment staff collected eight water samples for the identification and enumeration of aquatic organisms: one sample each of Buffalo Pound Filtration Plant raw water and treated water, four samples from various points in the Regina distribution system and four from the Moose Jaw distribution system. All results (Table 10) are based on single grab samples that were preserved with Lugol's solution.

The greatest number of algae were found in the Buffalo Pound Filtration Plant raw water as expected. There were 31 species from four taxonomic groups (Cyanophyta, Chlorophyta, Chrysophyta and Pyrrhophyta) present: 13 species with more than 10,000 organisms/L each and 4 species with more than 100,000 organisms/L each. The total number of algae in the raw water, $1.5 \times 10^6$ organisms/L, was reduced 99.5 per cent by the filtration plant;

TABLE 10

AQUATIC ORGANISMS IN WATER SAMPLES COLLECTED ON OCTOBER 11 AND 12, 1983

(NUMBER/L)

| | BUFFALO POUND FILTRATION PLANT | | REGINA DISTRIBUTION SYSTEM | | | | MOOSE JAW DISTRIBUTION SYSTEM | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | RAW WATER | TREATED WATER | SAMPLE #503 CENTRAL | SAMPLE #504 CENTRAL | SAMPLE #505 NORTHWEST | SAMPLE #506 SOUTH | SAMPLE #509 CENTRAL | SAMPLE #510 EAST | SAMPLE #511 WEST | SAMPLE #512 NORTH |
| PHYTOPLANKTON | | | | | | | | | | |
| 1. CYANOPHYTA | | | | | | | | | | |
| Anabaena flos-aquae | 337x10[1] | | 6 | 1 | 86 | 39 | 69 | 10 | 16 | 32 |
| Anabaena sp. | | 6 | | | | | | | | |
| Aphanizomenon flos-aquae | | 1 | | | | | | | | |
| Aphanothece nidulans | 337x10[1] | | | | | | | | | |
| Chroococcus limneticus | 108x10[3] | 92 | 36 | | 78 | 22 | 80 | 46 | 2 | 4 |
| Chroococcus sp. | | | | | | | | | 4 | 2 |
| Coelosphaerium Naegelianum | | 4 | | 1 | | 3 | | | 2 | 1 |
| Lyngbya limnetica | | | | | 2 | | | | | |
| Merismopedia sp. | | | | | 16 | | | | | |
| Oscillatoria Agardhii | | 3 | | | | | | | | |
| Synechococcus sp. | P | | | | | | | | | |
| Unidentified blue-greens | | 128 | 5 | | 2 | | | | | |
| 2. CHRYSOPHYTA | | | | | | | | | | 1 |
| Chrysococcus sp. | | | | | | | | | | |
| Cyclotella sp. | 774x10[2] | 2 | | | 1 | | 1 | | | |
| Diatoma elongatum | P | | | | | | | | | |
| Epithemia sp. | P | | | | | | | | | |
| Gomphonema sp. | P | | | | | | | | | |
| Gyrosigma sp. | | 1 | | | | | | | | |

TABLE 10 (continued)

AQUATIC ORGANISMS IN WATER SAMPLES COLLECTED ON OCTOBER 11 AND 12, 1983
(NUMBER/L)

| | BUFFALO POUND FILTRATION PLANT | | REGINA DISTRIBUTION SYSTEM | | | | MOOSE JAW DISTRIBUTION SYSTEM | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | RAW WATER | TREATED WATER | SAMPLE #503 CENTRAL | SAMPLE #504 CENTRAL | SAMPLE #505 NORTHWEST | SAMPLE #506 SOUTH | SAMPLE #509 CENTRAL | SAMPLE #510 EAST | SAMPLE #511 WEST | SAMPLE #512 NORTH |
| 2. CHRYSOPHYTA (continued) | | | | | | | | | | |
| Mallomonas tonsurata | $303x10^2$ | | | | | | | | | |
| Nitzschia sp. | P | | | | | | | | | |
| Rhoicosphenia curvata | P | | | | | | 1 | | | |
| Synedra sp. | $337x10^1$ | | | | | | 1 | | | |
| 3. EUGLENOPHYTA | | | | | | | | | | |
| Euglena sp. | | | | | | | 1 | | | |
| Trachelomonas sp. | | 1 | | | | | | | | |
| 4. CHLOROPHYTA | | | | | | | | | | |
| Chlamydomonas sp. | $202x10^2$ | | | | | | | | | |
| Coelastrum microporum | $606x10^2$ | 244 | 25 | 1 | | | | 9 | 21 | 5 |
| Crucigenia quadrata | | 16 | | | 6 | 5 | 20 | | | 4 |
| Crucigenia rectangularis | $808x10^2$ | | | | | 4 | 20 | | | |
| Crucigenia tetrapedia | | | | | | | | | | 1 |
| Monoraphidium obtusum | | 2 | | | | | | | | 6 |
| Oocystis Borgei | $572x10^2$ | | | | | | | | | |
| Oocystis parva | P | | | | | | | | | |
| Oocystis pusilla | $673x10^2$ | | | | | | | | | |
| Oocystis sp. | | 160 | 25 | | 35 | 12 | 45 | 17 | 28 | 144 |
| Pediastrum Boryanum | P | | | | 1 | | 1 | | | |
| Pediastrum duplex | | | | | | | | | | 1 |
| Planktosphaeria gelatinosa | P | 4 | | | | | | | 1 | |
| Scenedesmus acutus | $269x10^2$ | | | | | | | | | |
| Scenedesmus arcuatus | P | | | | | | | | | |
| Scenedesmus bicaudatus | P | | | | | | | | | |
| Scenedesmus ecornis | | | | | | | | | | 4 |

TABLE 10 (continued)

AQUATIC ORGANISMS IN WATER SAMPLES COLLECTED ON OCTOBER 11 AND 12, 1983

(NUMBER/L)

| | BUFFALO POUND FILTRATION PLANT | | REGINA DISTRIBUTION SYSTEM | | | | MOOSE JAW DISTRIBUTION SYSTEM | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | RAW WATER | TREATED WATER | SAMPLE #503 CENTRAL | SAMPLE #504 CENTRAL | SAMPLE #505 NORTHWEST | SAMPLE #506 SOUTH | SAMPLE #509 CENTRAL | SAMPLE #510 EAST | SAMPLE #511 WEST | SAMPLE #512 NORTH |
| 4. CHLOROPHYTA (continued) | | | | | | | | | | |
| Scenedesmus quadricauda | $195 \times 10^3$ | 14 | | | 4 | | 23 | 14 | 4 | |
| Scenedesmus spinosus | | | | | | | 4 | | | |
| Scenedesmus sp. | | | | | 8 | | | | | |
| Schroederia setigera | | | | | | | | 2 | | |
| Sphaerocystis schroeteri | P | 212 | | | 16 | | 24 | 16 | | |
| Tetraedron minimum | P | 1 | | | 1 | 1 | | | | 1 |
| Tetraedron muticum | P | | | | | | | | 4 | |
| Tetrastrum staurogeniaeforme | | | | | | | | | | |
| 5. PYRRHOPHYTA | | | | | | | | | | |
| Cryptomonas erosa | $512 \times 10^3$ | | | | | | | | | |
| Cryptomonas marssonii | $253 \times 10^3$ | | | | | | | | | |
| Cryptomonas rostratiformis | $673 \times 10^1$ | | | | | | 1 | | | |
| Cryptomonas sp. | | | | | | | | | | |
| Gymnodinium sp. | $101 \times 10^2$ | | | | | | | | | |
| MISCELLANEOUS ORGANISMS | | | | | | | | | | |
| Gallionella sp. (iron bacteria) | | | 68 | 91 | 35 | 40 | | 10 | | 1 |
| Amoebae | | | | | | | 12 | | | 3 |
| Ciliates | | | | | | | | | | 5 |
| Nematodes | | | | | | 2 | 1 | 4 | | 13 |
| Pine Pollen | | | | | | | | 1 | | |
| Rotifers | | | | | | | | 2 | | 3 |

NOTE:

P indicates present but not counted

* only 0.5 litre of sample concentrated due to large amount of debris present

however, 8.9 x $10^2$ organisms/L remained in the treated water. There were only four species with more than 100 organisms/L in the treated water. The remaining algae were primarily greens (Chlorophyta) and blue-greens (Cyanophyta).

Samples from the Regina distribution system averaged 1.2 x $10^2$ organisms/L which is slightly less than the number in the finished water at the filtration plant. The species present in the Regina system were often the same as those found in water from the filtration plant; minor differences are probably due to the small number of samples. The sample from the northwest area of Regina contained the greatest number of algae but generalizations should not be made from a single sample. Samples from the Moose Jaw distribution system yielded results similar to Regina samples; they averaged 1.7 x $10^2$ organisms/L.

A recent study of algal populations in Buffalo Pound Lake [18] found that increases in threshold odour numbers in the filtration plant raw water were highly correlated with increases in Anabaena in the lake. All samples collected from the Regina and Moose Jaw distribution systems in October, 1983, contained Anabaena Flos-Aquae, although the number of organisms was relatively low; the filtration plant removes approximately 99.5 per cent of the organisms from the raw water. The presence of these algal cells in the distribution system does not in itself prove that this species is a cause of odours in the water. The odour results from

organic compounds such as geosmin. Geosmin can be produced by actinomycetes and decaying algae. The previous section 4.2.5 comments on actinomycetes.

The 1983 investigation was restricted in the number of samples and sampling dates. Since only one sample was collected at each location, the significance of differences between locations could not be determined. Secondly, the samples were restricted to a two-day period in October. The number of phytoplankton in Buffalo Pound Lake usually increases during June to summer highs and decreases during late September or October to winter lows. For example, the total number of phytoplankton* per litre in Buffalo Pound Lake opposite the water filtration plant during 1981 [18] was $2.8 \times 10^6$ in mid-October and $3.2 \times 10^4$ in November **. Therefore, samples collected in October, 1983, probably lie somewhere in the fall transition zone. The 1983 results are valuable because they establish the number of organisms and the species actually present in the distribution systems at that time but they probably do not indicate the peak numbers.

Amoeboid and ciliate protozoa, nematodes and rotifers were not found in either sample from the Buffalo Pound Water Filtration Plant. Nevertheless, nematodes were found in three of the four samples from Moose Jaw and one of the samples from Regina.

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* Primarily blue-green algae.

** This comparison to the 1981 data can only be made in general terms. There are differences between seasons, species and counting methods.

Rotifers, ciliates and amoeboid protozoans were found in water samples from Moose Jaw. Iron bacteria were present in all samples from Regina and one sample from Moose Jaw. These results could be interpreted in several ways. The apparent lack of fauna in the filtration plant samples could be due to the treatment or the small sample size. The apparent increase in fauna in the distribution systems could be due to multiplication within the system itself or input from another source or both. Since iron bacteria are present in most ground water with a high iron content, the higher levels of iron bacteria and lower levels of fauna in the Regina system when compared to the Moose Jaw system could be a reflection of the ground water input in Regina.

In 1967, Dr. Zacharuk and Dr. Duerr, biologists at the University of Regina, reported [20] living organisms in tap water at the University and homes in Regina similar to those found in 1983.

The fauna in the 1983 samples were not identified to the species level; therefore whether any are parasitic remains unknown. Species of all groups are common everywhere in surface waters (including Buffalo Pound Lake). A standard surface water treatment plant will remove most of these organisms but 100 per cent removal could not be expected. The organisms identified could also enter the system at the water storage reservoirs or there could be some growth within the water storage reservoirs and distribution systems, particularly in areas where there may be low

flows and low or zero chlorine residuals. The data does not establish the presence or absence of a health hazard for these fauna but it does indicate that the water may not always be protected in all areas should contamination of the system occur.

## 4.4 Algal Toxins

No standard methods exist for the determination of algal toxins in water and the impacts, if any, of long-term ingestion of minute quantities of algal toxins are unknown. In 1980, a Medical Panel convened by the Buffalo Pound Water Administration Board recommended that bioassay tests be performed on baby chicks to empirically establish the safety of the treated water [21].

Samples of the treated water at the Buffalo Pound Filtration Plant were collected in 1982 during the winter and during the period of a blue-green algae bloom. "Chicken bioassays" were conducted using these samples and a summary report was provided to Environment in 1983. It states that:

"No harmful effects were seen on the chicks from either summer or winter Buffalo Pound water. This implies that if algae toxins were present, they were at low enough levels to have no observable effects.[22]"

Further research should be conducted to establish whether there is any long-term effect from ingesting minute amounts of algal toxins.

## 4.5 Trace Organics

The results and analyses for 77 organic compounds in the BPFP treated water are presented in Appendix B. All of the compounds were found to be less than detectable except two trihalomethanes. The detection limit was 10 ug/L. The chloroform concentration was 55 ug/L and the bromodichloromethane concentration was 33 ug/L. This would yield a trihalomethane concentration of 88 ug/L, well below the Saskatchewan Drinking Water Quality Objective [13] of 350 ug/L.

## 4.6 Chemical/Physical Tests

Field tests for pH, water temperature, specific conductivity and turbidity were included in the October, 1983, study of the Regina and Moose Jaw distribution systems. The pH remained close to neutral in all samples (Table 11). Specific conductivity and turbidity appeared to be slightly higher in the Moose Jaw system than at the filtration plant. The results for Regina were more variable with a maximum conductivity of 1100 USIE/CM and turbidity of 5.3 units occurring. These increases may be due to ground water input. The maximum turbidity exceeded the Saskatchewan objective and the federal guidelines of 5 units. The World Health Organization says the turbidity should preferably be below 1 unit for effective disinfection [16]. High levels of turbidity can protect micro-organisms from the effects of disinfection [14, 16], stimulate the growth of bacteria, exert a significant chlorine demand and reduce the aesthetic quality of the water.

TABLE 11

RESULTS OF FIELD TESTS, REGINA - MOOSE JAW DISTRIBUTION SYSTEMS, OCTOBER 1983

| | UNITS | NUMBER OF SAMPLES | MEAN | STANDARD DEVIATION | MEDIAN | MAXIMUM | 75TH PERCENTILE |
|---|---|---|---|---|---|---|---|
| Buffalo Pound | | | | | | | |
| Treated Water | | | | | | | |
| pH | | 2 | 7.6 | 0 | - | 7.6 | - |
| Water Temperature | °C | 5 | 8 | 0 | 8 | 8 | 8 |
| Specific Conductivity | USIE/CM | 2 | 520 | 0 | - | 520 | - |
| Turbidity | J.T.U. | 2 | 0.2 | 0 | - | 0.2 | - |
| Moose Jaw | | | | | | | |
| Municipal Distribution | | | | | | | |
| pH | | 20 | 7.6 | 0.2 | 7.6 | 8.0 | 7.8 |
| Water Temperature | °C | 20 | 17.1 | 3.1 | 17 | 23 | 18 |
| Specific Conductivity | USIE/CM | 20 | 689 | 62 | 673 | 850 | 700 |
| Turbidity | J.T.U. | 20 | 0.7 | 0.3 | 0.6 | 1.2 | 0.9 |
| Regina Municipal | | | | | | | |
| Distribution | | | | | | | |
| pH | | 42 | 7.5 | 0.2 | 7.5 | 8.0 | 7.7 |
| Water Temperature | °C | 42 | 14.5 | 2.4 | 14.0 | 20.0 | 15.0 |
| Specific Conductivity | USIE/CM | 41 | 720 | 201 | 750 | 1100 | 850 |
| Turbidity | J.T.U. | 42 | 1.6 | 1.3 | 1.1 | 5.3 | 2.3 |

Water temperatures were higher in the distribution systems than at the filtration plant. Temperatures of tap water in the cities were still high enough for some algal and bacterial growth to occur but these temperatures may not occur throughout the system since the treated water at Buffalo Pound was only 8°C.

The hardness of Regina water increases in the summer as more water is drawn from wells. The average hardness in February was 275 mg/L (as $CaCO_3$) while the average hardness in August was 410 mg/L (as $CaCO_3$) with a maximum of 604 mg/L. The Saskatchewan Drinking Water Quality Objective [13] of 800 mg/L was always met. The federal Guidelines for Canadian Drinking Water Quality 1978 [14] state that "Water supplies with a hardness greater than 200 mg/L are considered poor but have been tolerated by consumers; those in excess of 500 mg/L are unacceptable for most domestic purposes". The World Health Organization (WHO) guideline for hardness is 500 mg/L (as $CaCO_3$).

The levels of total dissolved solids (TDS) in Regina water also reached a maximum in August: the mean for that month was 761 mg/L and the maximum sample result was 1,015 mg/L. Means for all four seasons (Table 12) exceeded the maximum acceptable concentration of 500 mg/L in the federal guidelines [14]. The WHO guideline [16] is 1000 mg/L while the Saskatchewan drinking water objective [13] is higher at 1,500 mg/L. These guidelines relate to taste and palatability rather than health effects.

TABLE 12

SUMMARY OF CHEMISTRY RESULTS FOR WATER SAMPLES COLLECTED QUARTERLY AT 8 SITES IN THE REGINA DISTRIBUTION SYSTEM, 1983 (mg/L except Phenol in µg/L)

| | MEAN | STANDARD DEVIATION | MAXIMUM | MINIMUM | MEAN | STANDARD DEVIATION | MAXIMUM | MINIMUM |
|---|---|---|---|---|---|---|---|---|
| | FEBRUARY | | | | MAY | | | |
| Nitrate | 1 | 0 | <1 | <1 | 1 | 0.4 | 2 | <1 |
| Sulphate | 181 | 36 | 245 | 140 | 199 | 45 | 275 | 142 |
| Iron | 0.2 | 0.1 | 0.4 | 0.1 | 0.3 | 0.2 | 0.7 | 0.1 |
| pH | 7.4 | 0.1 | 7.5 | 7.3 | 7.8 | 0.3 | 8.1 | 7.4 |
| Total alkalinity (as $CaCO_3$) | 213 | 25 | 252 | 180 | 221 | 58 | 254 | 162 |
| Total hardness (as $CaCO_3$) | 275 | 52 | 356 | 200 | 317 | 115 | 548 | 204 |
| Calcium | 59 | 10 | 45 | 75 | 49 | 28 | 117 | 29 |
| Magnesium | 31 | 7 | 41 | 23 | 47 | 19 | 73 | 24 |
| Sodium | 74 | 2 | 76 | 70 | 64 | 7 | 70 | 48 |
| Bicarbonate | 259 | 29 | 307 | 220 | 270 | 71 | 420 | 198 |
| Chloride | 25 | 1 | 26 | 24 | 14 | 4 | 18 | 4 |
| Manganese | 0.10 | 0.08 | 0.19 | <0.01 | 0.28 | 0.33 | 1.08 | 0.07 |
| Total dissolved Solids | 629 | 79 | 766 | 530 | 644 | 144 | 927 | 487 |
| Phenol | 4 | 2 | 7 | <2 | 4 | 2 | 6 | <2 |
| | AUGUST | | | | NOVEMBER | | | |
| Nitrate | 1 | 0 | <1 | 1 | 1 | 0 | <1 | 1 |
| Sulphate | 227 | 70 | 316 | 142 | 195 | 28 | 244 | 146 |
| Iron | 0.2 | 0.1 | 0.3 | 0.1 | 0.2 | 0.1 | 0.3 | 0.1 |
| pH | 7.8 | 0.1 | 7.9 | 7.6 | 7.0 | 0.1 | 7.0 | 6.9 |
| Total alkalinity (as $CaCO_3$) | 260 | 87 | 362 | 158 | 218 | 31 | 267 | 161 |
| Total hardness (as $CaCO_3$) | 410 | 169 | 604 | 224 | 301 | 57 | 392 | 204 |
| Calcium | 85 | 37 | 130 | 38 | 66 | 13 | 83 | 42 |
| Magnesium | 48 | 19 | 71 | 29 | 33 | 7 | 45 | 24 |
| Sodium | 62 | 8 | 69 | 47 | 63 | 2 | 68 | 60 |
| Bicarbonate | 317 | 106 | 434 | 193 | 266 | 38 | 326 | 196 |
| Chloride | 18 | 7 | 26 | 6 | 18 | 2 | 22 | 16 |
| Manganese | 0.49 | 0.37 | 0.99 | 0.12 | 0.20 | 0.09 | 0.33 | 0.04 |
| Total dissolved Solids | 761 | 211 | 1015 | 528 | 640 | 83 | 777 | 491 |
| Phenol | 2 | 1 | 3 | <1 | 1 | 0 | <1 | 1 |

The Saskatchewan Drinking Water Quality Objective [13] and the federal guideline [14] for manganese, 0.05 mg/L was always exceeded by the seasonal means of Regina water samples. The highest mean, 0.49 mg/L, occurred in August. This objective has been established for aesthetic reasons since manganese can cause objectionable stains and tastes.

Some samples collected from the Regina distribution system in February and May, 1983, contained phenol levels exceeding the Saskatchewan Drinking Water Quality Objective and the federal guideline of 0.002 mg/L. Phenolic substances, particularly chlorophenols produced during chlorination, are known to cause taste and odour problems.

Results for heavy metals and other trace elements in water samples collected in August, 1983 (Table 13) were all well below the Saskatchewan Drinking Water Quality Objectives [13].

The quality of Moose Jaw water is generally quite good with respect to water chemistry (Table 14). The results all easily meet the Saskatchewan Drinking Water Quality Objectives [13].

The Buffalo Pound Filtration Plant reports the quality of the treated water monthly (Table 15); colour, temperature and turbidity are reported weekly (Table 16). Saskatchewan Environment has also analyzed two samples of treated water for trace elements including heavy metals (Table 17). The data were

TABLE 13

SUMMARY OF HEAVY METALS AND OTHER TRACE ELEMENTS IN WATER SAMPLES COLLECTED QUARTERLY AT EIGHT SITES IN THE REGINA DISTRIBUTION SYSTEM, AUGUST 1983

| | UNITS | MEAN | STANDARD DEVIATION | MAXIMUM | MINIMUM |
|---|---|---|---|---|---|
| Mercury | µg/L | 0.10 | 0.03 | 0.16 | 0.06 |
| Boron | mg/L | 0.13 | 0.04 | 0.17 | 0.08 |
| Cyanide | µg/L | 0.9 | 0.8 | 2.6 | 0.1 |
| Phenol | µg/L | 2 | 1 | 3 | <1 |
| Selenium | mg/L | 0.001 | 0 | <0.001 | <0.001 |
| Silver | mg/L | 0.001 | 0 | <0.001 | <0.001 |
| Arsenic | µg/L | 2.4 | 0.6 | 3.3 | 1.4 |
| Barium | mg/L | 0.054 | 0.064 | 0.21 | 0.013 |
| Cadmium | mg/L | 0.0005 | 0 | <0.0005 | <0.0005 |
| Chromium | mg/L | 0.006 | 0.002 | 0.010 | 0.004 |
| Copper | mg/L | 0.171 | 0.300 | 0.89 | 0.009 |
| Lead | mg/L | 0.003 | 0.002 | 0.006 | <0.002 |
| Zinc | mg/L | 0.021 | 0.016 | 0.057 | 0.008 |
| Color | A.P.H.A. | 3 | 1 | 5 | 2 |
| Turbidity | N.T.U. | 0.68 | 0.29 | 1.0 | 0.28 |
| Temperature | $^{o}C$ | 17 | 3 | 21 | 14 |
| Uranium | µg/L | 4.9 | 4.2 | 10±1 | <0.5 |
| Total Trihalomethanes | µg/L | 75.3 | 46.5 | 137 | 8 |

TABLE 14

SUMMARY OF CHEMISTRY RESULTS FOR WATER SAMPLES COLLECTED FROM THE MOOSE JAW DISTRIBUTION SYSTEM, 1983

| | | | | NOVEMBER | | |
|---|---|---|---|---|---|---|
| | UNITS | JANUARY | JULY | MEAN* | STANDARD DEVIATION | MAXIMUM |
| Calcium | mg/L | 39 | 38 | 33 | 1 | 33 |
| Magnesium | mg/L | 20 | 19 | 21 | 1 | 21 |
| Potassium | mg/L | 5.0 | 3.1 | 5.6 | 0.3 | 6.0 |
| Sodium | mg/L | 68 | 56 | 70 | 1 | 70 |
| Phosphorus, total | mg/L | -- | -- | 0.06 | 0.01 | 0.06 |
| Manganese | mg/L | -- | -- | 0.001 | 0.003 | 0.008 |
| Iron | mg/L | -- | -- | 0.083 | 0.030 | 0.120 |
| Aluminum | mg/L | 0.36 | 0.1 | 1.11 | 0.71 | 1.8 |
| Arsenic | µg/L | <0.5 | <0.5 | 0.8 | 0.6 | 1.7 |
| Barium | mg/L | 0.059 | 0.046 | 0.051 | 0.001 | 0.052 |
| Berillium | mg/L | <0.001 | <0.001 | 0.001 | 0 | <0.001 |
| Boron | mg/L | 0.07 | <0.01 | 0.07 | 0 | 0.07 |
| Cadmium | mg/L | <0.001 | <0.001 | 0.001 | 0 | <0.001 |
| Chromium | mg/L | 0.005 | 0.002 | 0.004 | 0.001 | 0.006 |
| Cobalt | mg/L | <0.001 | <0.001 | 0.001 | 0 | <0.001 |
| Copper | mg/L | 0.015 | 0.016 | 0.019 | 0.015 | 0.042 |
| Cyanide | µg/L | -- | -- | 2 | 1 | 3 |
| Lead | mg/L | <0.005 | <0.005 | 0.005 | 0.001 | 0.006 |
| Mercury | µg/L | <0.05 | <0.05 | 0.21 | 0.32 | 0.68 |
| Molybdenum | mg/L | <0.005 | <0.005 | 0.005 | 0.001 | 0.006 |
| Nickel | mg/L | 0.009 | <0.001 | 0.002 | 0.001 | 0.002 |
| Selenium | mg/L | <0.001 | <0.001 | 0.001 | 0 | <0.001 |
| Silver | mg/L | <0.001 | <0.001 | 0.001 | 0 | <0.001 |
| Titanium | mg/L | -- | -- | 0.001 | 0 | <0.001 |
| Uranium, total | µg/L | 6.0 | 4.8 | 0.6 | 0.1 | 0.8 |
| Vanadium | mg/L | <0.01 | <0.01 | 0.01 | 0 | <0.01 |
| Zinc | mg/L | 0.005 | 0.003 | 0.009 | 0.002 | 0.01 |

*Mean of 4 samples. "<" signs are ignored in calculating the mean.

TABLE 15

MONTHLY CHEMISTRY RESULTS FOR TREATED WATER SAMPLES COLLECTED AT THE BUFFALO POUND FILTRATION PLANT, 1983

| | | January | February | March | April | May | June | July | August | September | October | November | December |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Alkalinity | mg/L | 170 | 183 | 188 | 189 | 157 | 165 | 160 | 146 | 134 | 155 | 157 | 174 |
| Chloride | mg/L | 26 | 27 | 24 | 24 | 17.6 | 18.4 | 20 | 21 | 21 | 20 | 19.3 | 21.5 |
| Iron, Total | mg/L | 0.05 | 0.07 | 0.06 | 0.09 | 0.13 | 0.13 | 0.04 | 0.04 | 0.10 | 0.08 | 0.06 | 0.07 |
| Manganese, Total | mg/L | 0.05 | 0.04 | 0.03 | 0.03 | <0.02 | <0.02 | 0.03 | 0.03 | 0.03 | <0.02 | <0.02 | <0.02 |
| Calcium | mg/L | 42 | 44.2 | 45.2 | 47 | 40.6 | 41.4 | 37.0 | 27.6 | 26.7 | 29.1 | 31.2 | 35.7 |
| Magnesium | mg/L | 20.6 | 20.1 | 21 | 19.9 | 18.7 | 18.4 | 18.5 | 17.5 | 17.8 | 18.5 | 18.3 | 20.4 |
| Sulphate | mg/L | 111 | 121 | 117 | 99 | 93 | 89 | 99 | 98 | 121 | 104 | 100 | 123 |
| Sodium | mg/L | 61 | 65 | 70 | 73 | 57 | 63 | 53 | 60 | 64 | 64 | 70 | 69 |
| Phenolics | mg/L | | | | | <1 | <0.001 | 0.002 | 0.0015 | 0.002 | | 0.002 | <0.001 |
| pH | units | 7.15 | 7.05 | 7.05 | 7.2 | 7.3 | 7.35 | 7.4 | 7.2 | 7.0 | 7.17 | 7.2 | 7.2 |
| Nitrate-N | mg/L | 0.04 | 0.05 | 0.13 | <0.02 | 0.04 | <0.02 | 0.02 | 0.05 | 0.14 | 0.12 | 0.06 | 0.04 |
| Total Dissolved Solids | mg/L | 478 | 505 | 519 | 501 | 428 | 444 | 437 | 408 | 421 | 431 | 438 | 479 |
| Total Trihalomethanes | µg/L | 53 | 56 | 62 | 64 | 57 | 61 | 78 | 83 | 75 | 70 | 53 | 65 |



NOTE: Buffalo Pound Water Administration Board Data.

## TABLE 16

WEEKLY CHEMISTRY RESULTS FOR TREATED WATER SAMPLES COLLECTED AT THE BUFFALO POUND FILTRATION PLANT, 1983

| Parameter | January | | | | February | | | | March | | | | April | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1st week | 2nd week | 3rd week | 4th week | 1st week | 2nd week | 3rd week | 4th week | 1st week | 2nd week | 3rd week | 4th week | 1st week | 2nd week | 3rd week | 4th week |
| Colour (Pt/Co) | <5 | <5 | <5 | <5 | <5 | <5 | <5 | <5 | 5 | 5 | 5 | 5 | <5 | <5 | <5 | <5 |
| Temperature (°C) | 4.4 | 4.0 | 3.9 | 4.0 | 4.0 | 4.4 | 4.4 | 4.6 | 4.5 | 4.5 | 4.5 | 4.6 | 5.0 | 5.6 | 6.4 | 6.5 |
| Turbidity (NTU) | 0.27 | 0.31 | 0.22 | 0.23 | 0.22 | 0.16 | 0.25 | 0.16 | 0.17 | 0.21 | 0.19 | 0.19 | 0.17 | 0.19 | 0.26 | 0.21 |

| Parameter | May | | | | June | | | | July | | | | August | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1st week | 2nd week | 3rd week | 4th week | 1st week | 2nd week | 3rd week | 4th week | 1st week | 2nd week | 3rd week | 4th week | 1st week | 2nd week | 3rd week | 4th week |
| Colour (Pt/Co) | <5 | <5 | <5 | <5 | <5 | <5 | <5 | <5 | <5 | <5 | <5 | <5 | <5 | <5 | <5 | <5 |
| Temperature (°C) | 9.2 | 9.9 | 9.2 | 14.7 | 16.0 | 17.0 | 17.5 | 19.0 | 19.0 | 21.0 | 21.5 | 22.5 | 23.3 | 23.5 | 21.8 | 20.9 |
| Turbidity (NTU) | 0.21 | 0.19 | 0.15 | 0.15 | 0.17 | 0.12 | 0.11 | 0.11 | 0.13 | 0.13 | 0.13 | 0.13 | 0.14 | 0.10 | 0.11 | 0.16 |

| Parameter | September | | | | October | | | | November | | | | December | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1st week | 2nd week | 3rd week | 4th week | 1st week | 2nd week | 3rd week | 4th week | 1st week | 2nd week | 3rd week | 4th week | 1st week | 2nd week | 3rd week | 4th week |
| Colour (Pt/Co) | <5 | <5 | <5 | <5 | <5 | <5 | <5 | <5 | <5 | <5 | <5 | <5 | <5 | <5 | <5 | <5 |
| Temperature (°C) | 19.3 | 15.2 | 10.3 | 9.5 | 8.5 | 7.5 | 6.1 | 6.2 | 6.2 | 4.7 | 2.7 | 1.8 | 2.4 | 2.7 | 2.6 | 2.6 |
| Turbidity (NTU) | 0.10 | 0.09 | 0.10 | 0.11 | 0.13 | 0.14 | 0.14 | 0.13 | 0.16 | 0.16 | 0.18 | 0.15 | 0.15 | 0.17 | 0.16 | 0.20 |

NOTE: Buffalo Pound Water Administration Data.

TABLE 17

HEAVY METAL AND OTHER RESULTS FOR TREATED WATER SAMPLES COLLECTED AT THE BUFFALO POUND FILTRATION PLANT, 1983

| | UNITS | JANUARY | JULY |
|---|---|---|---|
| Calcium | mg/L | 37 | 36 |
| Magnesium | mg/L | 21 | 19 |
| Potassium | mg/L | 5.1 | 2.7 |
| Sodium | mg/L | 68 | 57 |
| Arsenic | µg/L | <0.5 | 0.9 |
| Mercury | µg/L | <0.05 | 0.05 |
| Selenium | mg/L | <0.001 | 0.001 |
| Cadmium | mg/L | <0.001 | <0.001 |
| Chromium | mg/L | 0.034 | 0.003 |
| Cobalt | mg/L | <0.001 | <0.001 |
| Copper | mg/L | 0.02 | 0.004 |
| Iron | mg/L | 0.076 | 0.015 |
| Lead | mg/L | <0.005 | <0.005 |
| Manganese | mg/L | 0.015 | <0.001 |
| Nickel | mg/L | 0.21 | 0.001 |
| Zinc | mg/L | 0.004 | 0.001 |
| Aluminum | mg/L | 0.55 | 0.1 |
| Barium | mg/L | 0.055 | 0.5 |
| Berillium | mg/L | <0.001 | <0.001 |
| Boron | mg/L | 0.07 | 0.05 |
| Molybdenum | mg/L | <0.005 | <0.005 |
| Silver | mg/L | <0.001 | <0.001 |
| Uranium, total | µg/L | 6.0 | 2.6 |
| Vanadium | mg/L | <0.01 | <0.01 |

compared with various water quality objectives and no potential water quality problems were discovered.

Herbicides, pesticides and several toxic organics were analyzed once at eight locations in Regina, at four locations in Moose Jaw, in Buffalo Pound Lake and in the treated water from the filtration plant. The herbicide 2, 4-D was detected in six of the Regina samples (Table 18) and in the raw and treated water at the filtration plant. The highest level detected, 2.7 ug/L, was present in the treated water but it was well below the Saskatchewan Drinking Water Quality Objctive of 0.1 mg/L (100 ug/L). Low levels of silvex and 2, 4, 5-T were also present in the treated water and low levels of lindane and oc BHC were detected in the Regina distribution system. Levels were well below objectives [13], [14], [16] where objectives are available.

Water from Regina ground water wells is routinely monitored for uranium and arsenic (Table 19). the maximum level of arsenic 35 ug/L, is below the Saskatchewan Drinking Water Quality Objective of 0.05 mg/L (50 ug/L). Health and Welfare Canada [14] has also set 0.05 ug/L as its maximum acceptable concentration. The maximum level of uranium in the wells was 35 ug/L which is higher than the federal guidelines and the Saskatchewan objective of 0.02 mg/L (20 ug/L). However, the objectives apply to drinking water in the distribution system while the results shown here come directly from wells. Well water is usually mixed with treated lake water in varying ratios thereby reducing the uranium concentration in the tap water.

TABLE 18

HERBICIDES AND PESTICIDES IN WATER SAMPLES FROM THE REGINA - MOOSE JAW DISTRIBUTION SYSTEM, 1983 (µg/L)

| | BUFFALO POUND LAKE OPPOSITE PLANT | BUFFALO POUND FINAL TREATED WATER | MOOSE JAW MUNICIPAL DISTRIBUTION | | | | REGINA MUNICIPAL DISTRIBUTION | |
|---|---|---|---|---|---|---|---|---|
| | JULY | JULY | NOVEMBER | | | | AUGUST | |
| | | | 1 | 2 | 3 | 4 | MEAN | MAXIMUM |
| 2,4-D | 0.18 | 2.72 | <0.1 | <0.1 | <0.1 | <0.1 | 0.3 | 0.6 |
| 2,4,5-T | 0.1 | 0.1 | <0.02 | <0.02 | <0.02 | <0.02 | -- | -- |
| Silvex | 0.05 | 0.13 | -- | -- | -- | -- | -- | -- |
| Aldrin | <0.04 | <0.04 | -- | -- | -- | -- | -- | -- |
| Alpha-BHC | <0.02 | <0.02 | <0.01 | <0.01 | <0.01 | <0.01 | -- | -- |
| Dieldrin | <0.02 | <0.02 | -- | -- | -- | -- | -- | -- |
| Endrin | <0.1 | <0.1 | -- | -- | -- | -- | -- | -- |
| Heptachlor | <0.03 | <0.03 | -- | -- | -- | -- | -- | -- |
| Heptachlor | <0.8 | <0.8 | -- | -- | -- | -- | -- | -- |
| Gamma-BHC | <0.02 | <0.02 | <0.01 | 0.08 | <0.01 | <0.01 | -- | -- |
| Methoxychlor | <1.0 | <1.0 | -- | -- | -- | -- | -- | -- |
| P.C.B. | -- | -- | -- | -- | -- | -- | <0.1 | <0.1 |
| Lindane | -- | -- | -- | -- | -- | -- | 0.01 | 0.03 |
| α BHC | -- | -- | -- | -- | -- | -- | 0.02 | 0.04 |

The uranium results from the Chemex Laboratory are much lower than the results from the SRC Laboratory (Table 20) but, in both data sets, the maximum level exceeded 0.02 mg/L. As a result of the high levels of uranium, the SRC experimented with TOPO Extractions of the water to remove potential interference before measuring uranium fluorimetrically. The results were then compared with results for the same samples using the Slow-Poke reactor. Because the two methods agreed, all further samples were then extracted before they were analyzed fluorometrically. This change took place in May. A summary of the data broken into two parts shows a reduction in the means after May but the changes made by SRC do not account for the differences between laboratories.

Table 21 shows the number of wells tested at the SRC during May to December. Nine values at 6 different wells out of 21 wells sampled had values over 20 ug/L.

Health and Welfare Canada have carried out laboratory research on the effects of uranium in test animals. The National Working Group on Drinking Water is reviewing that information and will likely revise the safe drinking water guideline upwards [12].

TABLE 19

URANIUM AND ARSENIC FOUND IN WATER SAMPLES TAKEN FROM GROUND WATER WELLS, REGINA, 1983

| | UNITS | NUMBER | MEAN | STANDARD DEVIATION | MAXIMUM |
|---|---|---|---|---|---|
| Uranium (SRC) | µg/L | 144 | 13.6 | 7.2 | 35 |
| Uranium (Chemex) | µg/L | 80 | 4.2 | 9.0 | 25 |
| Arsenic | µg/L | 79 | 6.9 | 7.9 | 35 |

TABLE 20

URANIUM FOUND IN GROUND WATER WELLS, REGINA 1983 (µg/L)

| | TESTED BY SRC | | TESTED BY CHEMEX | |
|---|---|---|---|---|
| | MEAN | STANDARD DEVIATION | MEAN | STANDARD DEVIATION |
| January to April | 20.4 | 6.7 | 2.1 | 3.1 |
| May to December | 11.8 | 6.2 | 3.8 | 5.7 |

TABLE 21

URANIUM LEVELS EXCEEDING 20 µg/L IN REGINA WELLS, 1983

| | TESTED BY SRC | |
|---|---|---|
| | NO. OF WELLS TESTED | NO. OF WELLS OVER 20 µg/L |
| May | 21 | 0 |
| June | 21 | 2 |
| July | 22 | 1 |
| August | 22 | 4 |
| September | 21 | 1 |
| October | 10 | 1 |
| November | 7 | 0 |
| December | 7 | 0 |

# APPENDIX A

APPENDIX A

A Report Submitted to Saskatchewan Environment
For Contract #41 (83/84)

# VIROLOGICAL EXAMINATION OF RAW AND TREATED WATERS FROM MOOSE JAW AND REGINA, SASKATCHEWAN.

SYED A. SATTAR

Department of Microbiology and Immunology,
School of Medicine, University of Ottawa,
451, Smyth Road, Ottawa, Ontario. K1H 8M5

December 1983

## BACKGROUND & INTRODUCTION

We were first contacted by Mr. C. L. Potter of Saskatchewan Environment on Sept.23rd., 1983, by telephone. During this conversation he briefed us on the questions raised about the quality of drinking water in Regina and Moose Jaw, Saskatchewan. It was indicated to us that Saskatchewan Environment was undertaking a variety of analyses on the raw and treated water samples from these two communities. We were asked to consider undertaking the testing of the water samples for the presence of detectable enteric vruses. A contract (#41-83/84) was subsequently drawn up outlining the details of such a testing program.

It was agreed that a trained person and all the necessary sample processing equipment and chemicals would be sent to Regina. Therefore, Susan Springthorpe, was sent to Regina on Oct. 11th. 1983. The collection and processing of the water samples was begun the next day. During the processing of the initial samples, Mrs. Springthorpe was also responsible for training a member of the Saskatchewan Environment staff (Mr. James Hoffman) in the proper procedures for sample collection and processing and storage of sample concentrates. The last water samples for this study were collected and processed on Oct.25th., 1983. The sample concentrates were received by us on October 26th., 1983.

## SOURCES OF RAW WATER

Buffalo Pound Water Treatment Plant(Fig.1a&b) provides all the drinking water for the city of Moose Jaw and up to 75% of that for Regina. This plant draws its raw water from Buffalo Pound Lake, which is a long, shallow body of water with a maximum depth of approximately 3 metres. The residence time of water in this lake has been estimated to be 1-2 years. As far as we have been able to find out, there are no regular and direct discharges, either treated or untreated, of human waste into this lake.

The plant provides the raw water with full conventional treatment. An underground pipeline system transports the finished water to Moose Jaw about 24 Km. to the south-west of the plant. A separate pipeline running south-east carries water approximately 65 Km. to Regina. In Regina, at certain points in the water distribution system, ground water,with chlorination only, is introduced to supplement the supply from Buffalo Pound Treatment Plant. Further details on the Buffalo Pound Water Treatment Plant are available in an information booklet (Aug. 1983) from the Buffalo Pound Water Administration Board.

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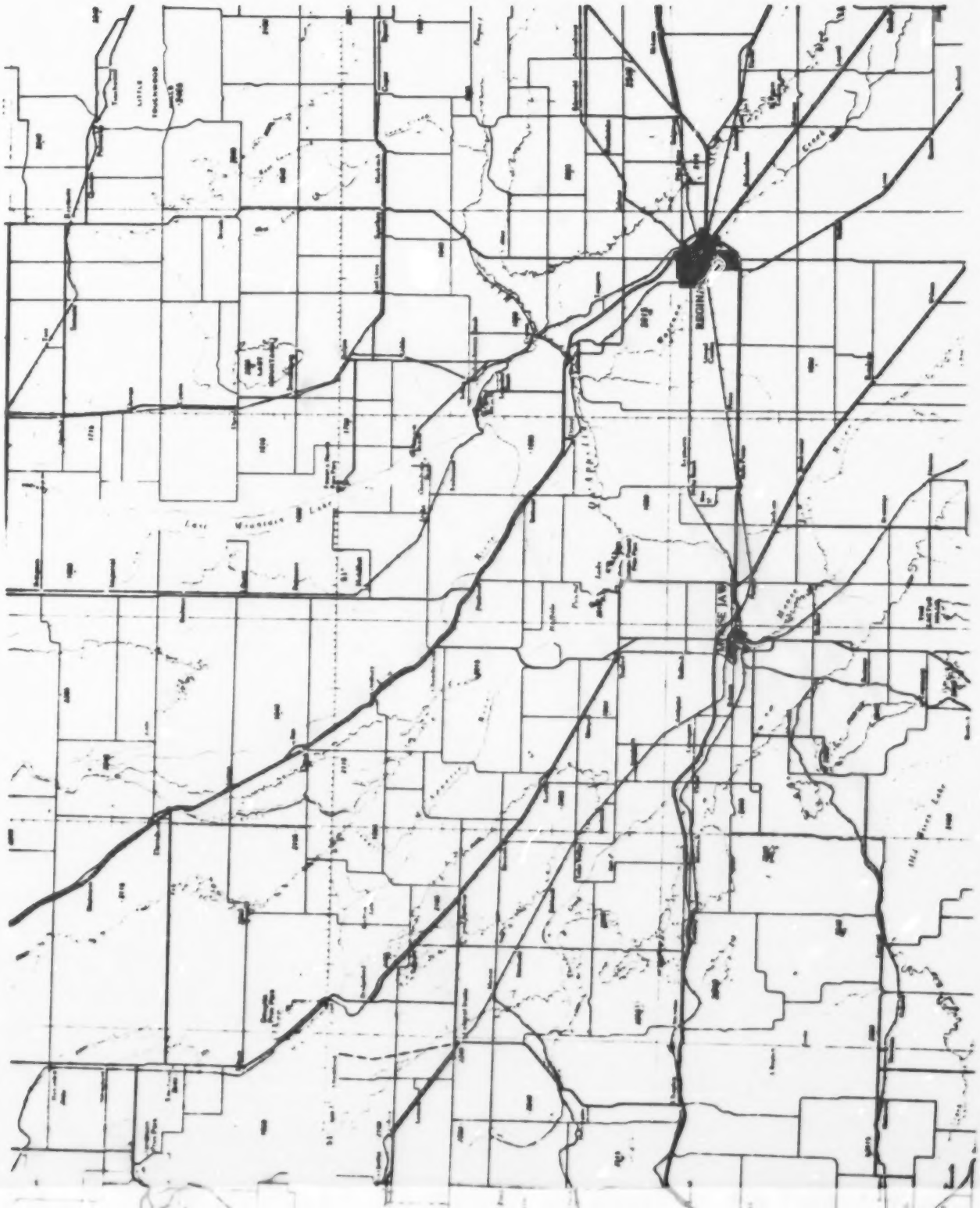
The following report details the methodology used for testing the water samples for viruses, gives and discusses the



results of such testing, and finally some conclusions and recommendations are made. Results of total coliform tests were provided by Saskatchewan Environment.

## MATERIALS & METHODS

### PREPARATION OF TALC-CELITE LAYERS

In this study the talc-Celite layer technique (Sattar & Ramia, 1979 a & 1979 b) was used for the first-step concentration of the water samples. Layers of a talc-Celite mixture (3:1) are formed under suction and sandwiched between two sheets of high wet-strength filter paper (Whatman # 114). A prefilter, with a pore diameter of 25µm (AP 25; Millipore Corp.), is placed on top of the talc-Celite layer. This is shown diagrammatically in Figure 2-inset.

### SAMPLE COLLECTION & PROCESSING

Raw water samples (40L each) were collected in the pumping station at Buffalo Pound Lake (BPL) using plastic containers. They were immediately transported to the filtration plant where temperature, turbidity and pH were measured. The sample to be processed was poured into stainless steel pressure vessels (20L). Preconcentration conditioning of the sample involved the addition of EBSS to a final concentration of 1:100 and the adjustment of sample pH to 6.0±0.2 with dilute HCl. The conditioned sample was then passed, under pressure, through a talc-Celite layer. One hundred ml. of 10 % FCS in normal saline was passed through the layer (under pressure) in order to elute any virus adsorbed to the layer. The eluate was further concentrated by overnight hydroextraction at 4°C (Ramia & Sattar, 1979). The material remaining in the dialysis tubing was resuspended in approximately 10mL of EBSS and sterilised by filtration through a 0.2 µm membrane. The concentrates thus obtained were stored at -80°C prior to inoculation into cell cultures.

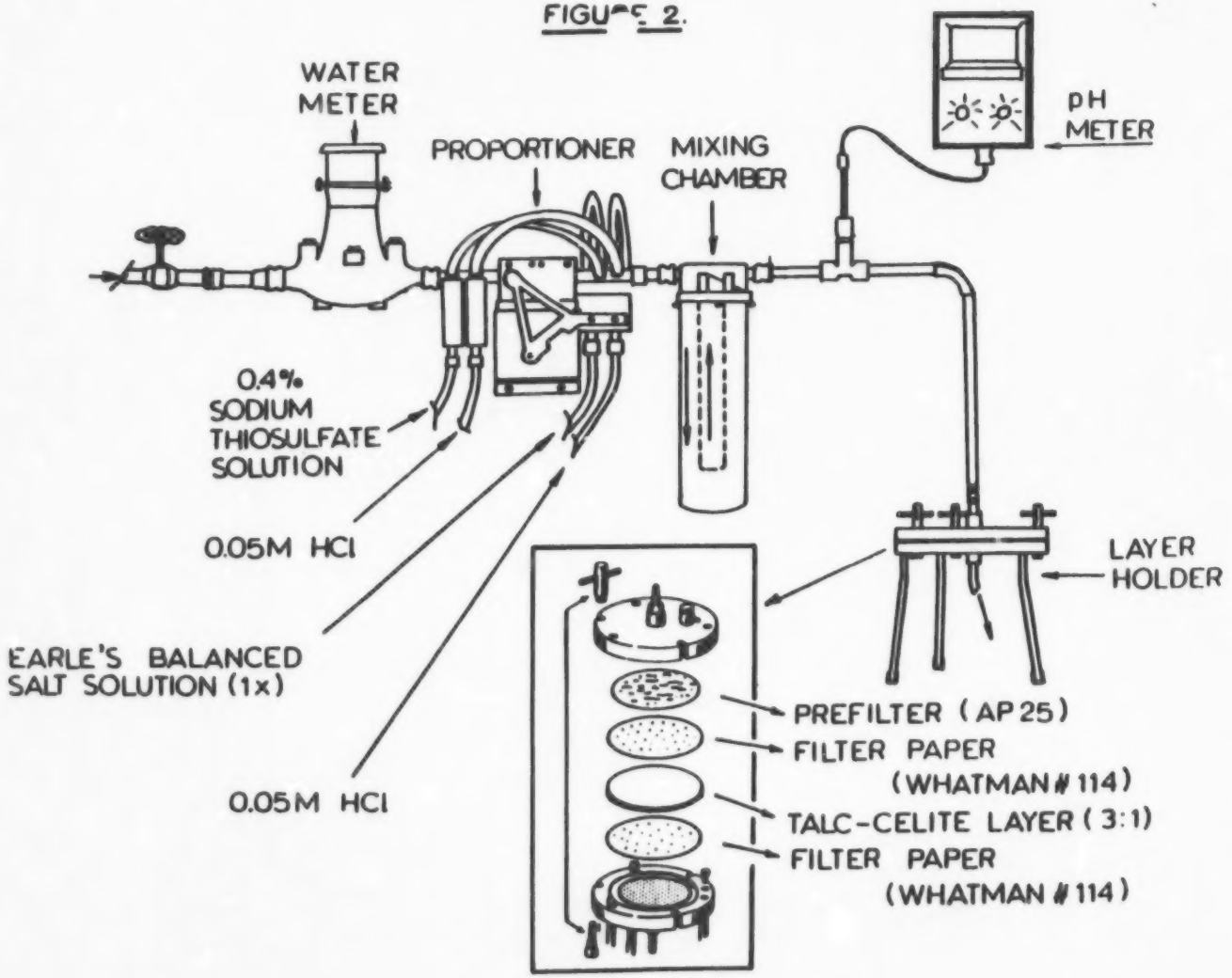
Samples of treated water were processed by direct hook-up to the distribution lines at the sampling locations; Buffalo Pound Water Treatment Plant (BPWTP) pump house, Moose Jaw Pumping Station Humford House in Regina. A total of 14 samples was obtained for testing. The processing set-up used for this purpose is shown in Figure 2. The rest of the sample concentration procedure was the same as described above for the raw water.

### CELLS

Cells from two different types of continuous lines were used for the detection of enteric viruses in the smple concentrates. BS-C-1 cells (Hopps et al., 1963) were obtained from Mr. Dan McLeod of the Laboratory Centre for Disease Control in Ottawa. A seed culture of the MA-104 line was originally received in our laboratory from Dr. H. Malherbe (Gull Labs, Utah).

The cells were routinely cultivated as monolayers in 75 $cm^2$ plastic culture flasks (Costar) using Eagle's minimal essential

FIGURE 2.


WATER METER
PROPORTIONER
MIXING CHAMBER
pH METER
0.4% SODIUM THIOSULFATE SOLUTION
0.05M HCl
EARLE'S BALANCED SALT SOLUTION (1x)
0.05M HCl
LAYER HOLDER
PREFILTER (AP25)
FILTER PAPER (WHATMAN # 114)
TALC-CELITE LAYER (3:1)
FILTER PAPER (WHATMAN # 114)

medium (MEM) in Earle's base (AUTOPOW; Flow Laboratories). Gentamicin (50 u g/ml) was added to the medium before autoclaving. It was further supplemented with sterile sodium bicarbonate, glutamine and fetal calf serum.

The cell monolayers were trypsinised using a mixture of trypsin and ethylene diamine tetra-acetate (EDTA) in phosphate-buffered saline. A split ratio of 1:4 was generally employed and monolayers for sample concentrate inoculation were put in 25cm $^2$ plastic cell culture flasks (Costar).

INOCULATION OF SAMPLE CONCENTRATES

Sample concentrates, undiluted and after appropriate dilution, were inoculated into cell cultures. Each monolayer was first washed once with EBSS and then was inoculated with 0.5 ml. of the material under test. Concentrates of finished water were inoculated without dilution whereas concentrates of raw water samples were inoculated both undiluted and after a ten-fold dilution in EBSS. Ten monolayers were used for each sample dilution. The inoculum was left on the cell monolayers for not less than one hour (at 37°C) to allow virus adsorption to the cells. Maintenance medium (with 2% FCS) was added to each culture and they were placed at 37°C.

All the inoculated cultures were inspected the next day to look for the presence of any obvious cytotoxic effects. Thereafter, they were examined daily under a phase contrast microscope for a period of two weeks. At the end of this period, the cultures were frozen and thawed three times and the material from them was subjected to a blind passage in fresh cultures of the same types of cells. Control cultures, which received EBSS as inoculum, were treated in the same manner as those receiving material from sample concentrates.

When no obvious cytopathic changes were detected in the inoculated cultures two weeks after blind passage, material from them was examined under the electron microscope. This was done in order to detect the presence of any non cytopathogenic viruses.

Sources of major consumable items used in this study are given in Table 1. Figure 3 summarises the major steps involved in the processing of samples for the concentration, detection and identification of viruses.

## RESULTS & DISCUSSION

The sample concentrates tested in this study showed no apparent cytotoxicity for the two types of cell cultures used for virus detection. No cytopathogenic viruses were detected in any of these 14 sample concentrates in either type of cell culture. In order to detect the presence of non-cytopathogenic viruses, the cell culture material was subjected to electron microscopic examination. All the samples proved to be negative for non-cytopathogenic viruses as well. Characteristics of the water samples tested and results of virus testing are given in

TABLE I Sources of Major Consumable Items used for Tissue Culture and Sample Processing

| ITEM | SPECIFICATION | MANUFACTURER | SUPPLIER |
|---|---|---|---|
| EBSS | powdered, without $NaHCO_3$ | Grand Island Biological Co. (GIBCO) | GIBCO |
| FCS | screened for viruses and mycoplasma | Flow Laboratories | Flow Laboratories |
| Gentamicin | 50 mg ml | Schering Corporation | Schering Corporation |
| L-Glutamine | 200 mM | Flow Laboratories | Flow Laboratories |
| MEM | autoclavable powder (Auto-Pow) (without L-glutamine and Na $HCO_3$) | Flow Laboratories | Flow Laboratories |
| Trypsin | lyophilised and irradiated, mycoplasma and parvovirus free, VMF-trypsin | Millipore Corporation | Millipore Corporation |
| Celite 503 | flux calcined diatomite | J. T. Baker | Canlab |
| Talc | magnesium silicate | J. T. Baker | Canlab |
| PEG | carbowax PEG 6000 powder | Fisher Scientific Co. | Fisher Scientific Co. |
| Filter Paper | Whatman #114, high wet strength | Whatman Ltd. | Canlab |
| Prefilter | type AP 25, borosilicate microfibre glass with an acrylic resin binder | Millipore Corporation | Millipore Corporation |

FIGURE 3.

Major Steps Involved in the Processing of Field Samples for the Concentration, Detection and Identification of Viruses

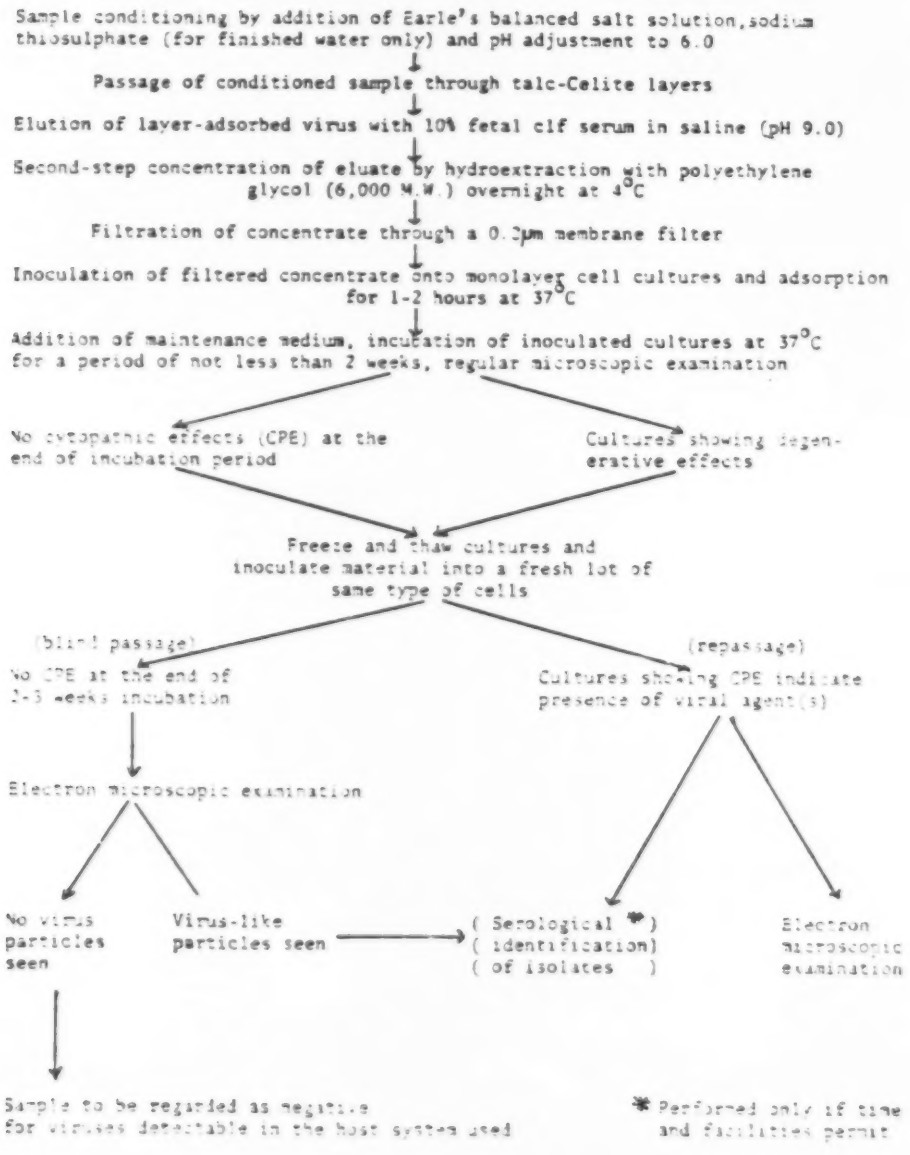

Sample conditioning by addition of Earle's balanced salt solution, sodium thiosulphate (for finished water only) and pH adjustment to 6.0
Passage of conditioned sample through talc-Celite layers
Elution of layer-adsorbed virus with 10% fetal calf serum in saline (pH 9.0)
Second-step concentration of eluate by hydroextraction with polyethylene glycol (6,000 M.W.) overnight at 4°C
Filtration of concentrate through a 0.2µm membrane filter
Inoculation of filtered concentrate onto monolayer cell cultures and adsorption for 1-2 hours at 37°C
Addition of maintenance medium, incubation of inoculated cultures at 37°C for a period of not less than 2 weeks, regular microscopic examination
No cytopathic effects (CPE) at the end of incubation period
Cultures showing degenerative effects
Freeze and thaw cultures and inoculate material into a fresh lot of same type of cells
(blind passage)
(repassage)
No CPE at the end of 2-3 weeks incubation
Cultures showing CPE indicate presence of viral agent(s)
Electron microscopic examination
No virus particles seen
Virus-like particles seen
( Serological * ) ( identification) ( of isolates )
Electron microscopic examination
Sample to be regarded as negative for viruses detectable in the host system used
* Performed only if time and facilities permit

TABLE 2 Characteristics of Water Samples Tested for Viruses and Results of Testing

| SAMPLE# | TYPE AND LOCATION | VOLUME PROCESSED (L) | pH | TURBIDITY (f.t.u.) | TEMPERATURE °C | TOTAL COLIFORM | CULTURES SHOWING CPE* / CULTURES INOCULATED | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Ma104 | BS-C-1 |
| 1 | Raw BPL | 40 | 8.6 | 3.0 | 8.0 | N/A | 0/10(0/10) | 0/10(0/10) |
| 2 | Raw BPL | 40 | 8.6 | 3.0 | 8.0 | N/A | 0/10(0/10) | 0/10(0/10) |
| 3 | Raw BPL | 40 | 8.6 | 3.0 | 8.0 | N/A | 0/10(0/10) | 0/10(0/10) |
| 4 | Raw BPL | 40 | 8.6 | 3.0 | 8.0 | N/A | 0/10(0/10) | 0/10(0/10) |
| 5 | Treated BPWTP | 300 | 7.8 | 0.18 | 8.0 | <1/100mL | 0/10 | 0/10 |
| 6 | Treated BPWTP | 282 | 7.4 | 0.13 | 6.0 | <1/100mL | 0/10 | 0/10 |
| 7 | Treated BPWTP | 318 | 7.8 | 0.13 | 6.0 | <1/100mL | 0/10 | 0/10 |
| 8 | Treated Moose Jaw | 291 | 7.6 | 0.19 | 8.0 | <1/100mL | 0/10 | 0/10 |
| 9 | Treated Moose Jaw | 264 | 7.6 | 0.19 | 8.0 | <1/100mL | 0/10 | 0/10 |
| 10 | Treated Moose Jaw | 300 | 7.6 | 0.19 | 8.0 | <1/100mL | 0/10 | 0/10 |
| 11 | Treated and ground Regina | 341 | 7.6 | 0.94 | 9.0 | <1/100mL | 0/10 | 0/10 |
| 12 | Treated and ground Regina | 286 | 7.5 | 2.96 | 9.0 | N/A | 0/10 | 0/10 |
| 13 | Treated and ground Regina | 345 | 7.5 | 3.02 | 9.0 | N/A | 0/10 | 0/10 |
| 14 | Treated and ground Regina | 355 | 7.3 | 1.53 | 10.0 | N/A | 0/10 | 0/10 |

* Figures in parentheses are results for ten-fold dilutions of sample concentrates

N/A = not available

The findings of this study should be viewed with the following limitations in mind:

1. Although important advances have been made in the techniques for the recovery of viruses from environmental samples, the systems available for the detection of enteric viruses contained in such samples still leave a lot to be desired. For example, the causative agents of hepatitis A and acute gastroenteritis still cannot be readily cultivated in the presently available cell culture systems.

2. In view of the limited funds and resources available for this study, only two cell types were used for the detection of cytopathogenic enteric viruses in the concentrates. Therefore, the samples examined could contain viral agents which were unable to produce apparent cytopathic changes in MA-104 or BS-C-1 cells.

3. Although no non-cytopathogenic viruses could be detected by electron microscopy, it should be noted that this requires large numbers (approx. $10^6$ particles /mL) of virus particles of identifiable morphology.

4. The process used for virus concentration from water is known to concentrate other types of organic matter contained in the samples. Such material of non-viral nature could interfere with the replication of viruses in cell cultures. This is particularly so for samples of raw water, and it is not uncommon to see the presence of viruses only in cultures inoculated with diluted rather than undiluted sample concentrates. In view of this, sample concentrates from raw water were tested both undiluted and after a 10-fold dilution.

5. The presence of detectable viruses in water samples may not always represent a potential threat to human health. In certain cases, viruses isolated from such samples turn out to be vaccine strains of poliovirus.

6. The virus content of surface waters, ground waters and sewage varies considerably, not only from season to season, but also from day to day (Sattar, 1978). Therefore, frequent sampling is required in order to get a representative picture of viral pollution of the water environment in any given setting. In this study, all the samples examined were collected within a period of 2 weeks in October 1983 and therefore not truly representative.

7. Based on average daily consumption figures for Regina and Moose Jaw (Buffalo Pound Water Treatment Plant Information Booklet; August 1983) and an average sample size of 300 L, it is apparent that only a very small proportion of the total daily consumption has been tested: about $5.5 \times 10^{-4}$% and $1.7 \times 10^{-3}$% for Regina and Moose Jaw respectively.

8. The drinking water for Regina represents a mixture of conventionally treated surface water from Buffalo Pound Lake and groundwater (chlorinated only) from the Regina aquifer. Viral pollution of ground waters as a result of sewage pollution is known to occur. Because ground waters are often used after chlorine treatment alone, such contamination has been known to result in outbreaks of hepatitis A and gastroenteritis (Marzouk et al.,1979; Keswick & Gerba, 1980).

9. The presently used bacterial indicators of sewage pollution have been shown to be unsatisfactory. Enteric viruses are more resistant to chlorine inactivation in comparison with fecal coliforms and many other bacteria. Therefore, the absence of indicator bacteria does not necessarily mean the absence of enteric viruses as well (Sattar, 1978). Certain types of enteric viruses have been demonstrated to withstand levels of chlorine much higher than are normally used for the disinfection of sewage and water (Tan & Schnagl, 1981; Sattar et al., 1984 a & 1984 b).

## CONCLUSIONS & RECOMMENDATIONS

1. No enteric viruses were detected in any of the 14 samples examined in this study.
2. The absence of any known sources of human waste into the Buffalo Pound Lake, together with the long residence time of the water reduce the risk of viral contamination from this source.
3. Because of the possibility of ground water contamination with sewage, it is considered important to monitor the quality of the water from the Regina aquifer.
4. Lake Diefenbaker is situated downstream from Calgary and Medicine Hat and it receives treated and untreated municipal wastes from these cities. If consideration is given to using Lake Diefenbaker as an alternative source of raw water, there is a possibility of higher levels of sewage pollution.

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# APPENDIX B

# RESULTS OF TESTING BPFP TREATED WATER

# FOR TRACE ORGANIC COMPOUNDS

EST 1880

# United States Testing Company, Inc.

Chemical Division

1415 PARK AVENUE • HOBOKEN, NEW JERSEY 07030 • 201-792-2400

## REPORT OF TEST

Buffalo Pound Water Administration Board
P.O. Box 1790
Regina, Sask, Canada S4P3C8

Attn: Les Gammie

April 22, 1983

TEST REPORT NO. 75104

SIGNED FOR THE COMPANY

BY Allan Tordini

Page 1 of 4

AT/mgs



THIS REPORT APPLIES ONLY TO THE STANDARDS OR PROCEDURES IDENTIFIED AND TO THE SAMPLE(S) TESTED. THE TEST RESULTS ARE NOT NECESSARILY INDICATIVE O REPRESENTATIVE OF THE QUALITIES OF THE LOT FROM WHICH THE SAMPLE WAS TAKEN OR OF APPARENTLY IDENTICAL OR SIMILAR PRODUCTS. NOTHING CONTAINE IN THIS REPORT SHALL MEAN THAT UNITED STATES TESTING COMPANY, INC., CONDUCTS ANY QUALITY CONTROL PROGRAM FOR THE CLIENT TO WHOM THIS TEST RE PORT IS ISSUED, UNLESS SPECIFICALLY SPECIFIED. OUR REPORTS AND LETTERS ARE FOR THE EXCLUSIVE USE OF THE CLIENT TO WHOM THEY ARE ADDRESSED AND THEY AND THE NAME OF THE UNITED STATES TESTING COMPANY, INC. OR ITS SEALS OR INSIGNIA, ARE NOT TO BE USED UNDER ANY CIRCUMSTANCES IN ADVER TISING TO THE GENERAL PUBLIC AND MAY NOT BE USED IN ANY OTHER MANNER WITHOUT OUR PRIOR WRITTEN APPROVAL. SAMPLES NOT DESTROYED IN TESTIN ARE RETAINED A MAXIMUM OF THIRTY DAYS.

I. SUBJECT:

One sample submitted and identified by the client as:

Drinking Water (Jan 17th 1983)
BPWTP TREATED WATER.

II. AUTHORIZATION:

P.O. #0732.

III. PURPOSE:

Analysis for Base/Neutral and Volatile Organics.

IV. PROCEDURE:

Sample was analyzed in accordance with methods presented in the following:

"Federal Register/Vol. 44, No. 233/Monday, December 3, 1979/Proposed Rules," Methods 625 (Acid and Base/Neutral Extractables) and 624 (Volatile Organics).

## V. Compounds Searched

### PURGEABLE ORGANICS (30 COMPOUNDS)

Acrolein
Acrylonitrile
Benzene
Toluene
Ethylbenzene
Carbon tetrachloride
Chlorobenzene
1,2-Dichloroethane
1,1-Dichloroethane
1,1-Dichloroethylene
1,1,2-Trichloroethane
1,1,2,2-Tetrachloroethane
Chloroethane
2-Chloroethyl vinyl ether
Chloroform
1,2-Dichloropropane
cis 1,3-Dichloropropylene
Methylene chloride
Methyl chloride
Methyl bromide
Bromoform
Dichlorobromomethane
1,1,1-Trichloroethane
Chlorodibromomethane
Tetrachloroethylene
Trichloroethylene
Vinyl chloride
1,2-trans-Dichloroethylene
trans-1,3-Dichloropropylene
Trichlorofluoromethane

### BASE/NEUTRAL EXTRACTABLE ORGANICS (47 COMPOUNDS)

1,2-Dichlorobenzene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
Hexachloroethane
Hexachlorobenzene
Hexachlorobutadiene
1,2,4-Trichlorobenzene
bis (2-Chloroethoxy) methane
Naphthalene
2-Chloronaphthalene
Isophorone
Nitrobenzene
2,4-Dinitrotoluene
2,6-Dinitrotoluene
4-Bromophenyl phenyl ether
bis (2-Ethylhexyl) phthalate
Di-n-octyl phthalate
Dimethyl phthalate
Diethyl phthalate
Di-n-butyl phthalate
Acenaphthylene
Acenaphthene
Butyl benzyl phthalate
2,3,7,8-Tetrachlorodibenzo-p-dioxin
Fluorene
Fluoranthene
Chrysene
Pyrene
Phenanthrene
Anthracene
Benzo (a) anthracene
Benzo (b) fluoranthene
Benzo (k) fluoranthene
Benzo (a) pyrene
Indeno (1,2,3-c, d) pyrene
Dibenzo (a,h) anthracene
Benzo (g,h,i) perylene
4-Chlorophenyl phenyl ether
3,3' - Dichlorobenzidine
Benzidine
bis (2-Chloroethyl) ether
1,2-Diphenylhydrazine
Hexachlorocyclopentadiene
N-Nitrosodiphenylamine
N-Nitrosodimethylamine
N-Nitrosodi-n-propylamine
bis (2-Chloroisopropyl) ether

## VI. RESULTS:

**Base/Neutral Extractables:**

| | |
|---|---|
| All | < 10. µg/L |

**Volatile Organics:**

| | |
|---|---|
| Chloroform | 55. µg/L |
| Bromodichloromethane | 33. µg/L |
| All others | < 10. µg/L |

"< " indicates not detected at or above the level shown.

# APPENDIX C

# REFERENCES

## APPENDIX C

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POOR

QUALITY

ORIGINAL